

APPENDIX J

EVALUATION OF BEDROCK TRANSPORT CHARACTERISTICS

TECHNICAL MEMORANDUM (Revised)

TO: Dr. Richard S. Williams, Solutia Inc.

FROM: James A. Kearley, Groundwater Services, Inc.

RE: Evaluation of Bedrock Transport Characteristics
Sauget Area 1, Sauget, Illinois

Introduction

This memorandum provides an evaluation of bedrock transport characteristics at Sauget Area 1 based on findings from the following sources: i) published studies of geology and groundwater occurrence in the American Bottoms region; ii) results of detailed field examination of rock cores collected during drilling of bedrock wells BR-G, BR-H, and BR-I; iii) results of thin section analysis of selected rock core samples from BR-G, BR-H, and BR-I; iv) results of a downhole survey at BR-I using several geophysical logging tools; and v) other observations at BR-I and a nearby piezometer, A1-19.

An earlier version of this memorandum was submitted to USEPA as part of *Response to March 2005 USEPA Comments on the DNAPL Characterization and Remediation Study, Sauget Area 1 Sites* Groundwater Services, Inc., (GSI), May 27, 2005. The memorandum has been revised to include additional data from BR-I and A1-19.

Background Information

The alluvial aquifer underlying the Sauget Area 1 sites consists primarily of silt, sand, and gravel and has a variable thickness ranging from approximately 105 to 116 feet, based on boring logs from piezometers installed in 2004 and 2005 during the DNAPL characterization and remediation study. Groundwater is present within the alluvial aquifer starting at a depth of approximately 15 to 20 ft below ground surface (bgs). The alluvial aquifer is underlain by limestone and dolomite bedrock.

Information from Published Studies Regarding Bedrock

Bedrock data from oil wells and oil test holes in the region indicate that the alluvial deposits in the American Bottoms are underlain by consolidated sedimentary rocks over 3800 feet thick, predominantly limestone and dolomite, with some sandstone and shale (Bergstrom and Walker, 1956). The bedrock immediately underlying the alluvial deposits in the American Bottoms is reported to be of Mississippian or Pennsylvanian age.

Bedrock has apparently never been an important source of water in the American Bottoms. Bergstrom and Walker, 1956 state that "no groundwater supplies are being withdrawn from bedrock formations in the American Bottoms..." and that water in the deeper bedrock is commonly too highly mineralized for use, "particularly at depths

greater than 370 to 420 feet below ground level on the flood plain..." A groundwater development report for the East St. Louis area prepared by the Illinois State Water Survey (Schicht, 1965) states that "because of the low permeability of the bedrock formations and poor water quality with depth, the rocks do not constitute an important aquifer in the area."

The Illinois Department of Natural Resources developed an American Bottoms regional model for groundwater flow in the alluvial aquifer (Clark, 1997), and one of the assumptions used in this model is that leakage from the underlying bedrock is negligible. "There is an insufficient pressure head difference to cause significant flow between the valley fill and the indurated carbonate rocks. This assumption allows treating the bottom of the valley fill as a zero flow boundary." (Clark, 1997)

Results of Field Examination of Rock Cores from BR-G, BR-H, and BR-I

Three bedrock wells (BR-G, BR-H, and BR-I) were drilled and installed at Sauget Area 1 in the spring of 2000 to obtain data regarding bedrock properties and to collect groundwater samples from the bedrock. Attachment A-1 contains the pages from the Field Sampling Report that provide detailed description of field procedures, including core examination procedures (O'Brien & Gere, 2000, Volume 2 of 9, pp. 125 to 138).

Mud rotary drilling methods were used to drill the boreholes for BR-G, BR-H, and BR-I. At each boring, a series of telescoping PVC casings was installed, with the innermost 4-inch diameter PVC casing extending from the ground surface to a depth of approximately five feet into the top of bedrock. Bedrock coring was then conducted beneath the 4-inch diameter casing to a depth of approximately 20 feet into competent bedrock using wireline coring barrels to generate a minimum 2-inch diameter core. The rock borehole below the 4-inch diameter PVC casing was left uncased. Groundwater samples were collected from the three bedrock wells using a Grundfos RediFlow pump.

Bedrock core samples were described by the field engineer on rock classification worksheets. Descriptions included the following properties: color, rock quality, porosity, beds, thickness, contact, foliation, joints, weathering, surface, hardness, texture, grain shape, sorting, mineral components, and rock classification. Tables A-1, A-2, and A-3 present a compilation of rock classification data for cores from borings BR-G, BR-H, and BR-I, respectively. Attachment A-2 includes the handwritten rock classification worksheets prepared by the field engineer during drilling (O'Brien & Gere, 2000, Volume 2 of 9, pp. 145A-1 to 145A-75). For evaluating transport characteristics of the bedrock, the most significant of the descriptive properties are rock quality designation, porosity, joints, and weathering.

Rock Quality Designation: At BR-G, rock quality was described as excellent and/or massive from 112 to 122 ft bgs, and fair (i.e., moderately fractured) from 122 to 131.5 ft bgs. At BR-H, rock quality was described as poor (i.e., highly fractured) from 111 to 112.5 ft bgs, and excellent and/or massive from 112.5 to 132 ft bgs. At BR-I, rock quality

was described as poor from 116 to 118 ft bgs, and sand was encountered from 118 to 120.5 ft bgs. Rotary drilling was resumed to reset the 4-inch diameter PVC well casing to a depth of approximately 124.75 ft bgs. Rock coring was then resumed, and rock quality was described as excellent and/or massive from 126.5 to 146.9 ft bgs.

The only locations with poor (i.e., highly fractured) rock were in the uppermost portions of the boreholes at BR-H and BR-I. This suggests that fluid transport in the bedrock may occur primarily in the weathered and fractured portion of the bedrock, immediately below the base of the alluvial aquifer.

Porosity: Rock porosity was generally described as “none” based on visual examination of the cores in the field. The rock classification worksheets do not indicate the presence of large pores, vugs, or solution cavities in the cores.

Joints and Weathering: Joints observed in individual core pieces were typically described as fine to very fine lines, sutures, or fractures, and were frequently observed to be clay-filled. Most were horizontal or sub-horizontal, but vertical or near-vertical joints were observed in some cores. Weathering or slight weathering was commonly noted on the surfaces at the top and/or bottom of the individual core pieces. A single core from BR-G, collected from 116.5 to 117 ft bgs, exhibited possible evidence of DNAPL. This core was reported to have a vertical fracture that was “slightly stained” with a “sweet odor.” No evidence of DNAPL was noted in any other rock cores from BR-G, BR-H or BR-I.

Results of Thin Section Analysis of Samples from BR-G, BR-H, and BR-I

A total of thirty rock samples, ten from each borehole, were submitted to American Petrographic Services, Inc. (APS) of St. Paul, Minnesota, for thin section evaluation under a petrographic microscope. Attachment A-3 contains copies of the APS reports, which include thin section photographs (O’Brien & Gere, 2000, Volume 2 of 9, pp. 147A-1 to 147A-21). As summarized on Table A-4, all the rock samples examined by APS were determined to be limestone, dolomitic limestone, or dolomite. The thin sections were evaluated by APS for relative porosity, and, as described below, most samples were described as having low or moderate-low porosity, which is generally consistent with the visual observations made by the field engineer during rock classification.

Eighteen of the thirty rock samples evaluated were described as having low or moderate-low porosity (see Table A-4), and these samples were generally characterized as “dense” or “well cemented.” Six rock samples had moderate porosity, with stylolites or dolomitized zones observed to be present. The six samples that were described as having high porosity were observed to have stylolites (two samples from BR-G), to be “dolomitized throughout” (two samples from BR-H), or to have “large cavities throughout” or “many lg. pores in dolomitized areas” (two samples from BR-I).

Although thin section analysis did indicate several samples with high relative porosity, these samples do not appear to be representative of the rock mass as a whole. As discussed above, the rock classification worksheets prepared by the field engineer give no indication of the presence of large pores, vugs, and/or solution cavities in any of the bedrock cores.

Results of Downhole Geophysical Surveys at BR-I

On October 5, 2005, Colog conducted the following downhole surveys in BR-I: optical televiewer, acoustic televiewer, three-arm caliper, fluid temperature/conductivity, and video. Key findings of the Colog survey were as follows:

- Well Construction: BR-I has a 4-inch diameter PVC casing to 124.75 ft bgs and an open borehole from 124.75 ft bgs to total depth of 146.9 ft bgs (see Figure 5). The interior diameter of the PVC casing is approximately 3.5 inches, and the diameter of the open borehole in the bedrock is approximately 2.5 inches.
- Well Integrity: Due to the presence of an oil substance starting at approximately 114.5 ft bgs, the bottom of the PVC casing could not be observed directly using the optical televiewer or video camera. However, the integrity of the inside of the PVC casing below 114.5 ft bgs appeared to be sound based on the acoustic televiewer and caliper logs. Variations in borehole diameter observed below the casing between 124.75 ft and 126.6 ft bgs could be due to changes in lithology (i.e., harder or softer layers of rock), the presence of closely spaced fractures in this interval, and/or some degree of drilling washout immediately below the casing.
- Fractures: Within the open-hole portion of the well, a total of 42 acoustic features were observed at depths between 125.2 ft bgs and 144.4 ft bgs. These acoustic features were ranked from 1 to 5 based on a ranking system developed by USGS. Of the 42 acoustic features observed in BR-I, there were 13 features with a rank of 3 (i.e., distinct feature with open aperture). There was one feature, at a depth of approximately 137.1 ft bgs, with a rank of 4 (i.e., very distinct, wide possible interconnected fracture), and this feature was also observed on the caliper log.
- DNAPL in BR-I: At the time of the Colog survey, the top of DNAPL appeared to be present at a depth of approximately 114.5 ft bgs, based on optical televiewer data and an observed change in fluid conductivity.
- Flow in Open-Hole Section of BR-I: There was minimal variation in fluid temperature in the open-hole section of BR-I, which suggests that flow is unlikely in the open-hole section under static conditions.

Origin of DNAPL in BR-I

The upper few feet of the bedrock is weathered. Pooled DNAPL is present in A1-19, which is located 15 feet from BR-I and is screened across the interface between the alluvial aquifer and the weathered bedrock (see Figure 5). The upper end of the open borehole at BR-I begins only a few feet below the apparent base of weathered bedrock. Although some acoustic features (i.e., fractures) were observed in the open borehole of BR-I, recovery tests indicate that the well yield of BR-I is low, at approximately 0.05 gpm. Based on these findings, the most likely explanation for the presence of DNAPL in BR-I is that the open borehole at BR-I is acting as a sump for accumulation of DNAPL that enters from the overlying alluvial aquifer and/or the upper few feet of weathered bedrock. Although the acoustic televiwer and caliper logs for BR-I did not show evidence of damage to the interior of the PVC casing, it is possible that some DNAPL could be entering the open borehole by leakage through the seal between the PVC well casing and the bedrock that the casing is seated in.

Evaluation of Transport Characteristics of the Bedrock

Published reports indicate that bedrock underlying the American Bottoms is not considered an important aquifer because of low permeability and poor water quality with depth (Schicht, 1965), and that there is an insufficient pressure head difference to cause significant flow between the alluvial aquifer and the underlying bedrock (Clark, 1997).

Results of rock core examination suggest that the upper few feet of bedrock underlying the alluvial aquifer are highly fractured. Below the weathered zone, bedrock at BR-H and BR-I is typically massive with few fractures. Bedrock at BR-G is massive in the upper ten feet (112-122 ft bgs) but was described as fair (moderately fractured) in the lower ten feet (122-131.5 ft bgs). Large pores, vugs, and/or solution cavities are not prevalent in the bedrock. There is some evidence of joints and weathering surfaces, although the joints were typically described as fine to very fine lines or sutures, and were often noted to be clay-filled.

Some acoustic features (i.e., fractures) were observed in the open borehole of BR-I, but recovery tests indicate that the well yield of BR-I is low (0.05 gpm). The most likely explanation for the presence of DNAPL in BR-I is that the open borehole is acting as a sump for accumulation of DNAPL that enters from the alluvial aquifer and/or the upper few feet of weathered bedrock.

These findings suggest that the upper few feet of the bedrock, which is weathered and fractured, is more likely to be a pathway for groundwater flow than the underlying competent bedrock.

REFERENCES

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- Clark, G.R., 1997. American Bottoms Regional Groundwater Flow Model. Illinois Department of Natural Resources, Office of Water Resources, Springfield, Illinois, August 1997.
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BEDROCK TRANSPORT EVALUATION

Sauget Area 1, Sauget and Cahokia, Illinois

TABLES

Table J-1:	Rock Classification Data for Boring BR-G
Table J-2:	Rock Classification Data for Boring BR-H
Table J-3:	Rock Classification Data for Boring BR-I
Table J-4:	Results of Thin Section Analysis of Bedrock Core Samples



Table J-1 - Rock Classification Data for Boring BR-G
Sauget Area 1 Sites
Sauget and Cahokia, Illinois

Sample Depth (ft/bgs)	Color	Rock Quality	Porosity	Beds	Thickness	Contact	Foliation	Joints	Weathering	Surface	Hardness	Texture	Grain Shape	Sorting	Mineral Components	Rock Classification
112 - 113.67 **	Light gray	Excellent, massive	None	Planar, thick	20 in.	Distinct	Planar	Faint filled fracture lines, a suture line at bottom	Exhibited at bottom, black, hard pitted	Solid	Moderate to hard	Micro-granular	Rounded	Well sorted	Trace to some white calcite?	Limestone
113.67 - 114.36	Light gray, NT	Excellent, massive	None	Planar, medium	8.25 in.	Distinct	Planar	Suture lines at top, clay filled fine fractures at bottom	Along joints	Solid	Moderate to hard	Granular, very fine to micro-granular	Rounded	Well sorted	Disseminated white specks (calcite)	Limestone
114.36 - 115.82 **	Light gray	Excellent	None	Planar, thick	17.5 in.	Distinct	Planar	Fine filled fractures at top and for ~1/2 inch thick at bottom, clay-filled; fracture at 14 inches has a rough and pitted surface	Exhibited at top and bottom	Solid	Moderate to hard	Granular to crystalline, very fine to micro	Rounded to sub-rounded	Well sorted	Disseminated white calcite?	Limestone
115.82 - 116.53 **	Light gray	Excellent, massive	None	Planar, medium	8.5 in.	Distinct	Planar	Fine filled fractures at top and bottom, clay filled; near-vertical fracture in middle	Exhibited in fractures	Solid	Moderate to hard	Very fine to micro- granular	Rounded to sub-rounded	Well sorted	None observed	Limestone
116.53 - 117.03	Light gray	Excellent, massive	None	Planar, medium	5.75 in.	Distinct	Planar	One nearly vertical from top to bottom	Pitted dark gray surfaces at top and bottom, vertical fracture, slightly stained, sweet odor	Solid	Moderate to hard	Very fine to micro- granular/crystalline	Rounded to sub-rounded	Well sorted	Calcite	Limestone
117.03 - 118.36	Light gray	Excellent, massive	None	Planar, thick	16 inches	Distinct	Planar	Horizontal fine lines; 2.5 inches from top and at bottom	Slight, exhibited at top and bottom, dark gray and pitted	Solid	Moderate to hard	Very fine to micro- granular	Sub-rounded, angular crystals	Well sorted	Calcite?	Limestone
118.36 - 118.51 **	Light gray	Excellent, massive	None	Planar, thin	3 in.	Distinct	Planar	Horizontal to nearly horizontal filled fractures	Exhibited at top and bottom as pitted, rough surfaces	Solid	Moderate to hard	Very fine to micro- granular	Sub-rounded	Well sorted	Some calcite	Limestone
118.51 - 119.43	Light gray	Excellent, massive	None	Planar, medium	11 in.	Distinct	Planar	Horizontal wavy filled fracture line, 45° angle fracture at bottom, dark gray rough pitted surface	Slight to moderate along fracture	Solid	Moderate to hard	Very fine to micro- granular	Sub-rounded, angular crystals	Well sorted	Calcite present as small crystals	Limestone
119.43 - 120.56	Light gray	Excellent	None	Planar, thick	13.5 in.	Distinct	Planar	Generally horizontal clay-filled fractures, one near-vertical healed fracture near top	Exhibited in fractures, and at top and bottom	Solid	Moderate to hard	Very fine to micro- granular, some crystallization at top	Sub-rounded, angular crystals	Well sorted	Calcite crystals	Limestone
120.56 - 121.12 **	Light gray	Excellent, massive	None	Planar, medium	6.75 in.	Distinct	Planar	Wavy, horizontal clay-filled lines of fracturing near bottom	Exhibited at top and bottom in clay filled fractures	Solid	Moderate to hard	Very fine to micro- granular, some crystallization	Sub-rounded to sub-angular	Well sorted	Disseminated white specks (calcite)	Limestone
121.12 - 121.76	Light gray	Excellent, massive	None	Planar, medium	6.5 in.	Distinct	Planar	Nearly horizontal wavy fracture lines at top	Exhibited as clay seams at top and bottom, pitted at bottom	Solid	Moderate to hard	Very fine to micro- granular, some crystallization	Rounded to sub-rounded	Well sorted	With calcite	Limestone
122 - 122.71 **	Light gray	Fair	None	Planar, medium	8.5 in.	Distinct	Planar	Horizontal and vertical fracture lines	Slight at top and bottom	Solid	Moderate to hard	Very fine to micro- granular	Rounded	Well sorted	Some calcite	Limestone
122.71 - 123.31	Light gray	Fair	None	Planar, medium	7.25 in.	Distinct	Planar	Horizontal wavy fracture	Slight at top and bottom	-	Moderate to hard	Very fine to micro- granular	Rounded to sub-rounded	Well sorted	A few white specks	Limestone
123.31 - 123.56	Light gray	Fair	None	Planar, thin	3 in.	Distinct	Planar	Wavy fine lines at bottom	Slight at top and bottom	Solid	Hard	Very fine to micro- granular, flaky break planes	Sub-rounded	Well sorted	Calcite	Limestone
123.56 - 123.83	Light gray	Fair	None	Planar, thin	3.25 in.	Distinct	Planar	None	Slight at top	Solid	Hard	Micro-granular	Rounded	Well sorted	-	Limestone
123.83 - 124.46 **	Light gray	Fair	None	Planar, medium	7.5 in.	Distinct	Planar	None present within; clay filled at bottom	At bottom	Solid	Hard	Micro-granular	Rounded to sub-rounded, some darker gray specks and spots	Well sorted	Calcite present	Limestone
124.46 - 124.63	Light gray	Fair	None	Planar, thin	2 in.	-	Planar	Wavy, horizontal; one clay filled vertical fracture	Along clay filled fracture at top	Solid	Moderate to hard	Micro-granular	Rounded to sub-rounded	Well sorted	Some calcite	Limestone
124.63 - 125.30 (11+ pieces)	Light gray	Fair	None	Planar, thin	~8 in. total, 11 + pieces	Distinct	Planar	Wavy fractures	None	Solid	Moderate to hard	Micro-granular	Rounded	Well sorted	-	Limestone



Table J-1 - Rock Classification Data for Boring BR-G
Sauget Area 1 Sites
Sauget and Cahokia, Illinois

Sample Depth (ft/bgs)	Color	Rock Quality	Porosity	Beds	Thickness	Contact	Foliation	Joints	Weathering	Surface	Hardness	Texture	Grain Shape	Sorting	Mineral Components	Rock Classification
125.30 - 125.45	Light gray	Fair	None	Planar, thin	1.75 in.	Distinct	Planar	Healed vertical fracture	None observed	Solid	Moderate to hard	Micro-granular	Rounded	Well sorted	-	Limestone
125.45 - 125.76	Light gray	Fair	None	Planar, thin	3.75 in.	Distinct	Planar	Generally horizontal wavy filled fractures, one healed fracture at 45° angle	At top, clayey	Solid	Moderate to hard	Micro-granular	-	-	-	Limestone
125.76 - 125.91	Light gray	Fair	None	Planar, thin	1.75 in.	Distinct	Planar	None observed	Top and bottom, slight	Solid	Moderate to hard	Micro-granular	-	-	-	Limestone
125.91 - 126.32 (four pieces)	Light gray	Fair	None	Planar, medium	4.9 in.	Distinct	Planar	Wavy, fine lines, clay filled	Exhibited along fractures	Solid	Moderate to hard	Micro-granular	-	-	-	Limestone
126.32 - 126.62	Light gray	Fair	None	Planar, thin	3.625 in.	Distinct	Planar	Horizontal filled fine fractures, two healed vertical fractures	Slight at top and bottom	Solid	Moderate to hard	Micro-granular	-	-	Clay in fractures	Limestone
126.62 - 126.79	Light gray	Fair	None	Planar, thin	2 in.	Distinct	Planar	Clay-filled fractures at top and bottom	Top and bottom	Solid	Moderate to hard	Micro-granular	-	-	-	Limestone
126.79 - 128.17 **	Light gray	Fair	None	Planar, thick	16.5 in.	Distinct	Planar	Horizontal, clayey	Slight exhibited at top and bottom	Solid	Moderate to hard	Micro-granular	-	-	-	Limestone
128.17 - 129.09 **	Light gray	Fair	None	Planar, medium	11 in.	Distinct	Planar	Horizontal, wavy fine fractures, clay filled	Slight at top and bottom	Solid	-	Micro-granular	-	-	Some white specks	Limestone
129.09 - 130.46	Light gray	Fair	None	Planar, thick	16.5 in.	Distinct	Planar	Many fine wavy essentially horizontal lines at top half, fewer in bottom	Slight at top and bottom, bottom dark gray and pitted	Solid	Moderate to hard	Micro-granular	-	-	-	Limestone
130.46 - 130.80	Light gray	Fair	None	Planar, medium	4.125 in.	Distinct	Planar	Fine horizontal lines	Dark gray pitted clay at top	Solid	Moderate to hard	Micro-granular	-	-	Pyrite infilling one _____ fraction and as a ¾ in. long X ¼ in wide	Limestone
130.80 - 131.34 **	Light gray, some darker gray specks and splotches	Fair	None	Planar, medium	6.5 in.	Distinct	Planar	Horizontal fine lines	Slight at bottom	Solid	Moderate to hard	Micro-granular	-	-	-	Limestone
131.34 - 131.51	Light gray	Fair	None	Planar, thin	2.0 in.	Distinct	Planar	Horizontal fine fracture	Slight at top and bottom	Solid	Moderate to hard	Micro-granular	-	-	Some white outlines, fossils (?)	Limestone

Notes:

1) Rock classification worksheets for BR-G are in pp. 145A-1 to 145A-30 in Soil, Ground Water, Surface Water, Sediment, and Air Sampling Field Sampling Report, Sauget Area 1 – Volume 2 of 9, O'Brien & Gere Engineers, September 2000.

2) ** = A portion of this core was submitted to American Petrographic Services, Inc. for visual documentation of relative porosity and for thin section evaluation under a petrographic microscope.

3) A rock classification worksheet was not found for the following interval: 121.76-122 ft bgs.



Table J-2 - Rock Classification Data for Boring BR-H
Sauget Area 1 Sites
Sauget and Cahokia, Illinois

Sample Depth (ft/bgs)	Color	Rock Quality	Porosity	Beds	Thickness	Contact	Foliation	Joints	Weathering	Surface	Hardness	Texture	Grain Shape	Sorting	Mineral Components	Rock Classification
111 - 112.5 (eight pieces) **	Fresh surface is med. gray to med. light gray	37%, Poor, ——	None	Horizontal, breaks along clay seams range from 2-7 cm thick (very thin to thin)	Smooth	Distinct between sections	Fissile (see Note 4)	Planar, usually along horizontal lines clay _____ within section is stylolite (wavy & _____), very thin to thin	Fresh	Solid (see Note 5)	Hard	Very fine (much less than 1 mm), micro- granular, occasional brachiopod fossil	Matrix too fine to tell, some inclusions are rounded to very angular	General ly very well sorted	Traces of black specks (hornblende), pyrite, possibly aragonite or calcite	Limestone, some shell fossils
112.5 - 113.81 **	Light gray, N7	Massive	None	Planar, thick	15.75 in.	Upper – broken, rounded; lower – w/ striae distinct	Planar	Stylolite at ~60° angle at top; stria upper 5 inches and lower ¾ of an inch	Slight at both ends	Solid	Hard	Micro-granular, some brachiopod fossils	Rounded, ~0.2 mm or less	Well sorted	Disseminated calcite w/ limestone matrix	Limestone
113.81 - 114.81	Light gray, N7	Massive	None	Planar, Medium-thick	12 in.	Distinct	Planar	Wavy striae starting at 7” below top and going to bottom, generally lines but up to 2 mm, darker gray	None, slight at top and bottom	Solid	Hard	Micro-granular, some brachiopod fossil	Rounded	Well sorted	Disseminated calcite?	Limestone
114.81 - 117.81 **	Med light gray, N6 in top 15.5”; light gray 15.5 to 26.75”; med gray 26.75-36”	Massive	None	Planar, thick; wavy lines	36 in.	Distinct	Planar and wavy	Wavy striae nearly vertical at top; horizontal near 27 inches from top	Top and bottom evidence	Solid	Hard	Micro-granular	Rounded	Well sorted	Disseminated white calcite? One thin black metallic line at ~15.75 in. from top	Limestone (breaks through grains at top, around grains at bottom 9 inches)
117.81 - 118.81 **	Light gray	Massive	None	One, planar, medium	10.75 in.	Distinct	_____	Irregular break	Slight at top and bottom	Solid	Hard	Micro-granular, occasional brachiopod shell imprint	Rounded	Well sorted	Approx. ½ inch wide, band at bottom contains dull black specks, 3mm wide, pale green horizontal band @ 7.5 “ from top	Limestone
118.81 - 119.10	Light gray, N7	Massive	None	Planar, thin	3.25 in.	Distinct	A few wavy lines	Planar	Slight	Solid	Hard	Micro-granular	Rounded	Well sorted	None	Limestone
119.10 - 120.31 **	Light gray, N6	Massive	None	Planar, thick	14.5 in.	Distinct	Wavy lines near top and bottom, clay filled	Planar, wavy, clay filled	Slight at top and bottom	Solid	Hard	Micro-granular	Rounded	Well sorted	Disseminated white calcite? Crystals; green specks & streaks	Limestone
120.31 - 120.62	Light gray, N7	Massive	None	Planar, thin	3.75 in.	Distinct	Wavy, horizont al to nearly vertical	Top and bottom	At top and bottom	Solid	Hard	Micro-granular	Rounded	Well sorted	Minor calcite?	Limestone
120.62 - 121.10	Light gray	Massive	None	Planar, thin	2 – 3 in.	Distinct	Wavy planar	Wavy	At top and bottom	Solid	Moderate to hard	Micro-granular	Rounded to sub-rounded	Well sorted	Calcite ? as rounded ½ nodules	Limestone



Table J-2 - Rock Classification Data for Boring BR-H
Sauget Area 1 Sites
Sauget and Cahokia, Illinois

Sample Depth (ft/bgs)	Color	Rock Quality	Porosity	Beds	Thickness	Contact	Foliation	Joints	Weathering	Surface	Hardness	Texture	Grain Shape	Sorting	Mineral Components	Rock Classification
121.10 - 121.93 **	Light gray	Massive	None	Planar, medium	10 in.	Distinct	Horizontal, wavy	Planar	At top and bottom	Solid	Moderate to hard	Micro-granular	Rounded	Well sorted	Calcite as rounded ½ nodules	Limestone
122.5 - 123.13 **	Light gray, N7	Excellent, massive	None	Planar, medium	10 in.	Distinct	Planar	Vertical to inclined lines, filled with clay	Top and bottom are slightly pitted and clayey	Solid	Hard	Very fine to micro-granular, flaky on broken surfaces, some brachiopod fossil impressions	Rounded	Well sorted	None observed	Limestone
123.13 - 124.42	Light gray, N7	Excellent, massive	None	Planar, thick	15.5 in.	Distinct	Planar	Fine, wavy, clay filled horizontal to inclined lines; stylolites occasionally	Slight to fresh; top and bottom exhibit pitted clayey surface	Solid	Moderate to hard	Micro-granular, <<1mm	Rounded to sub-rounded	Well sorted	None additional observed	Limestone
124.42 - 125.05	Light gray, N7	Excellent, massive	None	Planar, medium	10 in.	Distinct	Planar	Wavy, filled fracture at top	Exhibited at top and bottom; pitted clay-filled fracture	Solid	Moderate to hard	Very fine to micro-granular	Rounded	Well sorted	A few white calcite?	Limestone
125.05 - 127.51 **	Light gray, N7	Excellent, massive	None in rock; possibly in thin fractures	Planar, thick	29.5 in.	Distinct	Planar	Wavy lines in middle section and at lower end; possibly clay filled fractures, generally a much darker gray on fracture surface (N3)	Only in fractures, top and bottom	Solid	Moderate to hard	Very fine to micro-granular	Rounded	Well sorted	Pyrite on one fracture line	Limestone
127.51 - 128.99	Light gray	Excellent, massive	None, except in fractures	Planar, thick	17.75 in.	Distinct	Planar	Wavy fracture lines, clay filled pyrite in fracture @ 3 inches from bottom; black and pitted in middle fracture.	None within; along larger fractures – slight	Solid	Moderate to hard	Very fine to micro-granular	Rounded to sub-rounded; some crystals angular	Well sorted	Calcite, pyrite in one fracture	Limestone
128.99 - 129.91 **	Light gray, N7	Excellent, massive	None	Planar, medium	11 in.	Distinct	Planar	Wavy filled fractures and sutures; dark gray clay filled	Along fracture lines	Solid	Moderate to hard	Very fine to micro-granular	Sub-rounded to sub-angular	Well sorted	Calcite	Limestone
129.91 - 130.64	Light gray	Excellent, massive	None	Planar, medium, one thin bed at bottom	8.75 in.	Distinct	Planar	Clay-filled, wavy planar fracture lines	Exhibited in fractures	Solid	Moderate to hard	Very fine to micro-granular	Rounded to sub-rounded	Well sorted	-	Limestone
130.64 - 131.04	Light gray, N7	Massive	None	Planar, medium 5/8 in. thick	4.75 in., clay/shale layer at bottom	Distinct	Planar	Wavy fine fracture lines	Exhibited in clay-filled fracture	Solid	Moderate to hard	Very fine to micro-granular	Sub-rounded	Well sorted	Calcite	Limestone
131.04 - 131.87 **	Light gray	Excellent, massive	None	Planar, medium	10 in.	Distinct	Planar	None	Exhibited at top in clay-filled fractures	Solid	Moderate to hard	Micro-granular	Rounded	Well sorted	-	Limestone

- Notes:
- 1) Rock classification worksheets for BR-H are in pp. 145A-31 to 145A-49 in Soil, Ground Water, Surface Water, Sediment, and Air Sampling Field Sampling Report, Sauget Area 1 – Volume 2 of 9, O'Brien & Gere Engineers, September 2000.
 - 2) ** = A portion of this core was submitted to American Petrographic Services, Inc. for visual documentation of relative porosity and for thin section evaluation under a petrographic microscope.
 - 3) A rock classification worksheet was not found for the following interval: 121.93-122.5 ft bgs.
 - 4) For the sample interval from 111-112.5 ft bgs, the description under Foliation had the following additional information: "Some white specks to pieces up to ½ inch long, rounded to blocky, may be calcite as they effervesce in HCl."
 - 5) For the sample interval from 111-112.5 ft bgs, the description under Surface had the following additional information: "Solution at _____ in clay at 112.5 ft below existing grade."



Table J-3 - Rock Classification Data for Boring BR-I
Sauget Area 1 Sites
Sauget and Cahokia, Illinois

Sample Depth (ft/bgs)	Color	Rock Quality	Porosity	Beds	Thickness	Contact	Foliation	Joints	Weathering	Surface	Hardness	Texture	Grain Shape	Sorting	Mineral Components	Rock Classification
111 - 113 (five pieces)	Very light gray, then light gray	Poor	Some	Planar, thin	1.5 to 3.75 in.	Distinct	Planar	Wavy fine lines nearly horizontal	Exhibited along fracture line	Solid	Moderate to hard	Very fine to micro-granular	Rounded to sub-rounded	Well sorted	White specks	Limestone
116 - 118 (ten pieces)	Light gray	Poor	None	Planar, very thin to medium	0.125 to 4 in.	Distinct	Planar	Horizontal	None observable	Solid	Moderate to hard	Very fine to micro-granular	-	Well sorted	White specks throughout	-
118 - 120.5	The rock classification worksheet indicates that sand was present in this interval.															
120.5 - 126.5	The rock classification worksheet indicates that no rock coring was conducted from 120.5 to 126.5 ft. This interval was drilled out using mud rotary drilling, and the 4-inch diameter PVC casing was reset.															
126.5 - 127.02 (five pieces)	Light olive gray	Excellent, massive	None	Planar, very thin to thin	0.25 to 2 in.	Distinct	Planar	Wavy, nearly horizontal	Slight at top and bottom of piece 2, bottom of pieces 4 & 5 dark gray & pitted	Solid	Moderate to hard	Very fine to micro-granular	Rounded to sub-rounded	Well sorted	Some white specks and nodules	Limestone
127.02 - 127.54	Light gray	Excellent	None	Planar, medium	6.25 in.	Distinct	Planar	Wavy, horizontal, clay filled	Slight, pitted surfaces at top and bottom	Solid	Moderate to hard	Very fine to micro-granular, flaky breakage	Sub-rounded to sub-angular	Well sorted	Disseminated white specks, calcite	Limestone
127.54 - 128.54 **	Light gray	Excellent	None	Planar, thick	12 in.	Distinct	Planar	Horizontal, wavy fine lines and suture lines ~2 inches from bottom	Slight, pitted surfaces at top and bottom of piece	Solid	Hard	Very fine to micro-granular	Sub-rounded to angular	Well sorted	Calcite, a few white specks	Limestone
128.54 - 129.35	Light gray	Excellent	None	Planar, medium	9.75 in.	Distinct	Planar	Very fine lines, horizontal to sub-horizontal	Pitted surface at top, dull clayey at bottom	Solid	Moderate to hard	Very fine to micro-granular	Sub-rounded to sub-angular	Well sorted	Disseminated white specks	Limestone
129.35 - 132.04 **	Light gray	Excellent	None	Planar, very thick	32.25 in.	Distinct	Planar	Planar, suture-like, horizontal, three	Slight at top and bottom	Solid	Moderate to hard	Very fine to micro-granular	Sub-rounded to sub-angular	Well sorted	Disseminated white specks	Limestone
132.04 - 132.35 (two pieces)	Light gray	Excellent	None	Planar, very thin to thin	0.75 and 3 in.	Distinct	Planar	One in center of piece 11, wavy, filled	Pitted surface on bottom of piece 11	Solid	Moderate to hard	Very fine to micro-granular	Sub-rounded to angular	Well sorted	Clay, calcite	Limestone
132.35 - 132.77	Light gray	Excellent	None	Planar, medium	5 in.	Distinct	Planar	Wavy fine lines, medium gray, N5, bands at top and bottom	N5, fine pitting in bottom of piece	Solid	Moderate to hard, dark gray bands slightly more soft than middle	Very fine to micro-granular	Rounded (dark bands), sub-rounded to sub-angular	Well sorted	Calcite	Limestone
132.77 - 133.87	Light gray	Excellent	None	Planar, thick	13 in.	Distinct	Planar	As wavy fine filled lines	Slight at top and bottom	Solid	Moderate to hard	Very fine to micro-granular	Sub-rounded to sub-angular	Well sorted	White specks	Limestone
132.87 - 132.97	Light gray	Excellent	None	Planar, thin	1.25 in.	Distinct	Planar	Wavy, filled fine horizontal lines	Slight at top and bottom ends	Solid	Moderate to hard	Micro-granular	-	-	-	Limestone
132.97 - 133.99 **	Light gray	Excellent	None	Planar, thick	12.25 in.	Distinct	Planar	Few horizontal wavy fine lines	Slight at top and bottom, pitted surfaces	Solid, some darker gray shapes, possibly fossils	Moderate to hard	Micro-granular	Rounded	Well sorted	-	Limestone
133.99 - 134.59	Light gray	Excellent	Solid	Planar, medium	7.25 in.	Distinct	Planar	As fine wavy filled horizontal lines	Slight at pitted surfaces on top and bottom	Solid	Moderate to hard	Micro-granular	Rounded	Well sorted	-	Limestone
134.59 - 135.42 **	Light gray	Excellent	None	Planar, medium	10 in.	Distinct	Planar	None observed	Slight, pitted top surface	Solid	Moderate to hard	Micro-granular	Rounded	Well sorted	CaCO ₃	Limestone
136.5 - 137.44	Light gray	Excellent	None	Planar, medium	11.25 in.	Distinct	Planar	None	Slight top and bottom	Solid	Moderate to hard	Micro-granular	Sub-rounded to sub-angular	Well sorted	CaCO ₃	Limestone



Table J-3 - Rock Classification Data for Boring BR-I
Sauget Area 1 Sites
Sauget and Cahokia, Illinois

Sample Depth (ft/bgs)	Color	Rock Quality	Porosity	Beds	Thickness	Contact	Foliation	Joints	Weathering	Surface	Hardness	Texture	Grain Shape	Sorting	Mineral Components	Rock Classification
137.44 - 137.61	Light gray	Excellent	None	Planar	2.125 in.	Distinct	Planar	Fine, wavy, horizontal filled lines	Pitted surface at top, smooth clayey (shale?) layer at bottom	Solid	Moderate to hard	Micro-granular	Sub-rounded to sub-angular	Well sorted	CaCO ₃	Limestone
137.61 - 138.05 **	Light gray	Excellent	None	Planar	5.25 in.	Distinct	Planar	-	Slight at top and bottom	Solid	Moderate to hard	Micro-granular	Sub-rounded to sub-angular	Well sorted	CaCO ₃	Limestone
138.05 - 139.47 **	Light gray	Excellent	None	Planar, thick	17 in.	Distinct	Planar; white irregular shapes in bottom 7.5 in.	Horizontal to sub-horizontal fine wavy filled lines	Dull clay surfaces on top and bottom surfaces	Solid top 9.5 in.; small pits scattered in bottom 7.5 in.	Moderate to hard	Micro-granular	-	Well sorted	White crystals in bottom 7.5 inches, do not effervesce in HCl	Limestone
139.47 - 141.72	Light gray	Excellent	None	Planar, thick	27 in.	Distinct	Planar	No jointing except at bottom	Thick pitted surface at bottom	Somewh at pitted in top 3.5 inches	Moderate to hard	Micro-granular	-	-	A bear-trap shape in top 5 inches has apparent pyrite in it	Limestone
141.72 - 142.03 (three pieces)	Light gray	Excellent	None	Planar	3.75 in. total, each ~1.25 in.	Distinct	Planar	Multitude of fine wavy sub-horizontal lines; slightly larger fractures separate pieces	Along fracture lines separating pieces	Solid	Moderate to hard	Micro-granular	-	-	-	Limestone
142.03 - 144.21 **	Light gray	Excellent	None	Planar, thick; gray irregular shaped blotches in top 2/3, white blotches in bottom 1/3	26.125 in.	Distinct	Planar	As wavy, fine, sub-horizontal fine lines	Slight at top and bottom ends	Solid	Moderate to hard	Micro-granular	Rounded	Well sorted	CaCO ₃	Limestone
144.21 - 144.56	Light gray	Excellent	None	Planar, medium	4.25 in.	Distinct	Planar	As fine wavy lines at top	As pitted surfaces on top and bottom	Solid	Moderate to hard	Micro-granular	Rounded	Well sorted	-	Limestone
144.56 - 145.27	Light gray	Excellent	None	Planar, medium	8.5 in.	Distinct	Planar	As fine horizontal to sub-horizontal lines	Slight as pitted clay surfaces at top and bottom	Solid	Moderate to hard	Micro-granular	-	-	-	Limestone
145.27 - 145.70 **	Light gray	Excellent	None	Planar, medium	5.125 in.	Distinct	Planar	Clay filled at top, black stained and pitted on bottom	Pitted black bottom	Solid; pitted filled fracture in middle	Moderate to hard	Micro-granular	Rounded	Well sorted	Trace pyrite	Limestone
145.70 - 146.91 **	Light gray	Excellent	None	Planar, thick	14.5 in.	Distinct	Planar	One sub-horizontal, stylolite in middle	Pitted surface on top of core	Solid	Moderate to hard	Very fine to micro-granular	Rounded	Well sorted	Some faint white blotches	Limestone

- Notes:
- 1) Rock classification worksheets for BR-I are in pp. 145A-50 to 145A-75 in Soil, Ground Water, Surface Water, Sediment, and Air Sampling Field Sampling Report, Sauget Area 1 – Volume 2 of 9, O'Brien & Gere Engineers, September 2000.
 - 2) ** = A portion of this core was submitted to American Petrographic Services, Inc. for visual documentation of relative porosity and for thin section evaluation under a petrographic microscope.
 - 3) Rock classification worksheets were not found for the following intervals: 113-116 ft bgs and 135.42-136.5 ft bgs.

Table J-4
Results of Thin Section Analysis of Bedrock Core Samples
 Sauget Area 1 Sites, Sauget and Cahokia, Illinois

Sample Depth (ft bgs)	Lithology	Relative Porosity	Comments
Well BR-G			
112.20 – 112.46	Dolomitic limestone, biosparite	Moderate	Dolomitized throughout
114.74 – 115.07	Limestone, pel-biosparite	Low	Well cemented
116.11 – 116.53	Limestone, oo-pel-biosparite	Low	Well cemented
118.36 – 118.51	Limestone, oo-pel-biosparite	High	Many stylolites
120.56 – 120.89	Limestone, pel-biosparite	Low	Few scattered interfragment pores
122.41 – 122.71	Limestone, biomicrite	Mod-Low	Dense, 2 thin stylolites
124.17 – 124.46	Limestone, oo-pel-biosparite	Low	Dense
126.79 – 127.13	Limestone, oo-pel-biosparite	Low	Dense
128.42 – 128.73	Limestone, oo-pel-biosparite	High	Concentrations of sub-parallel stylolites
130.80 – 131.10	Dolomitic limestone, biosparite	Moderate	Dolomitized zones throughout
Well BR-H			
111.83 – 112.19	Limestone, biosparite	Moderate	Some sutured stylolites
113.46 – 113.81	Limestone, biosparite	Moderate	Some crude stylolites
115.76 – 116.03	Dolomitic limestone	High	Dolomitized throughout
118.04 – 118.46	Calcitic dolostone, biosparite	High	Dolomitized throughout
119.87 – 120.29	Limestone, oo-pel-biosparite	Low	Dense sparite cement
121.43 – 121.63	Limestone, biosparite	Moderate	Some stylolite swarms
122.50 – 122.79	Limestone, biosparite	Mod-Low	One stylolite swarm
125.30 – 125.59	Limestone, oo-pel-biosparite	Mod-Low	A few pores in drusy sparry cavities
128.99 – 129.39	Limestone, pel-biosparite	Moderate	Some crude stylolites
131.04 – 131.43	Limestone, biomicrite	Low	Dense micrite matrix
Well BR-I			
127.54 – 127.92	Limestone, pel-biosparite	Low	Dense sparite cement
129.85 – 130.27	Pel-biosparite	Low	Dense, drusy sparite cement, syntaxial cement growth surrounds fossil fragments
131.27 – 131.55	Limestone, pel-biosparite	Low	Dense sparite cement
133.08 – 133.41	Limestone, pel-biomicrite	Low	Dense micrite matrix
134.59 – 135.01	Limestone, oo-pel-biosparite	Low	Dense sparite cement
137.61 – 137.84	Limestone, pel-biosparite	Low	Very dense and fine sparite cement
138.93 – 139.31	Dolostone, micro sparite	High	Large cavities throughout
142.57 – 142.87	Dolomitic limestone, biomicrite	High	Many large pores in dolomitized areas
145.27 – 145.46	Limestone, pel-micrite	Low	No visible porosity
146.63 – 146.88	Limestone, biomicrite	Low	Dense micrite matrix

Notes:

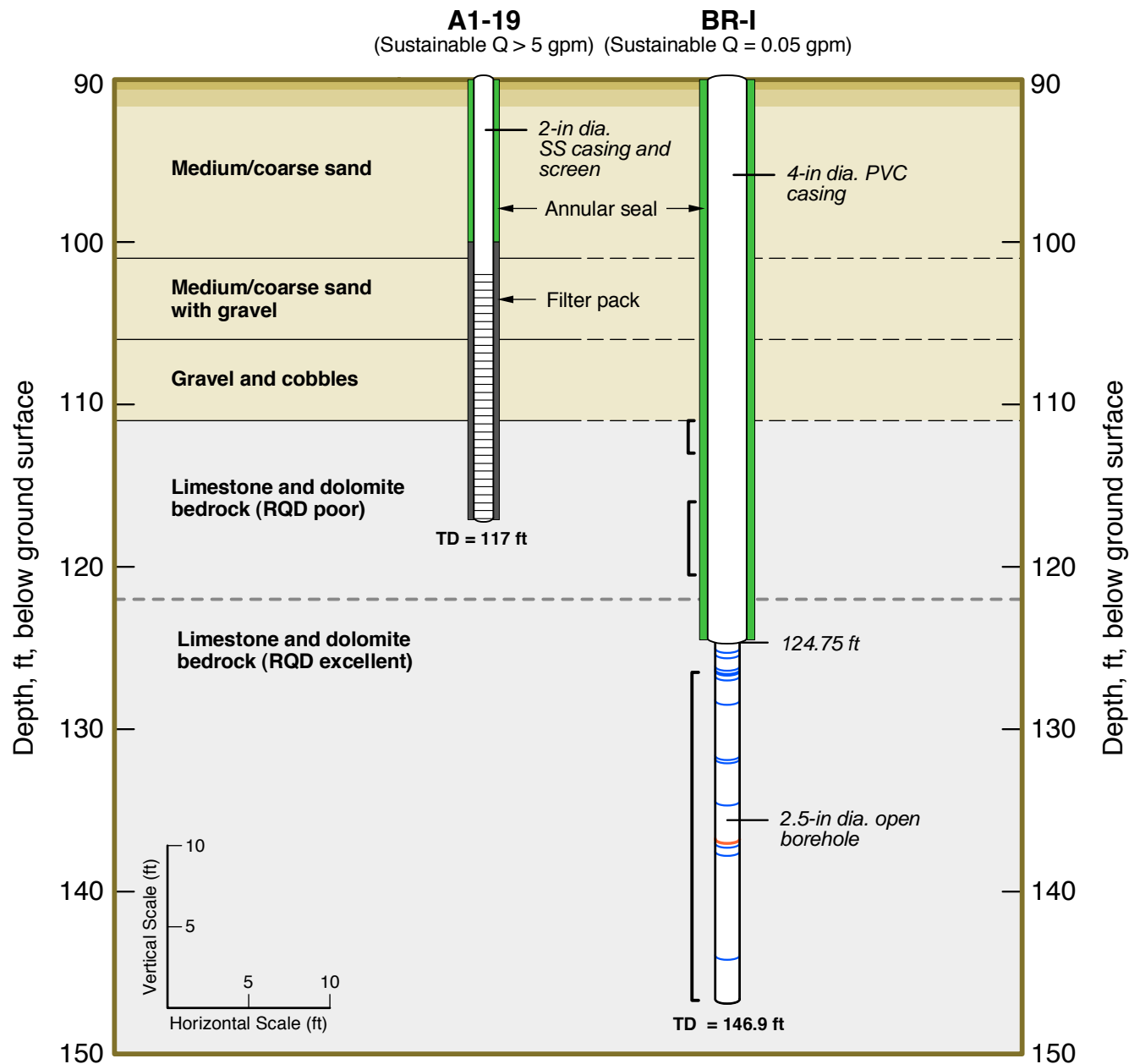
- Thin section analyses conducted by American Petrographic Services and documented in pp. 147A-1 to 147A-21 in Field Sampling Report, Sauget Area 1 – Volume 2 of 9, O'Brien & Gere Engineers, September 2000.
- A stylolite is defined as a "surface or contact, usually in carbonate rocks, that is marked by an irregular, interlocking penetration of the two sides: columns, pits, and teeth-like projections on one side fit into their counterparts on the other." (Dictionary of Geological Terms, Third Edition, 1984).

BEDROCK TRANSPORT EVALUATION

Sauget Area 1, Sauget and Cahokia, Illinois

FIGURE

Figure J-1 Detailed Cross Section at BR-I



- Notes:** 1) During drilling of BR-I, a 4-inch diameter PVC casing was installed and grouted in place, and wireline cores were collected from 111-113 ft and 116-120.5 ft bgs. Sand was observed in the wireline core collected from 118-120.5 ft bgs. The 4-inch diameter PVC casing was then removed and re-set to a depth of approximately 124.75 ft bgs.
- 2) Acoustic features were identified in an acoustic televiewer survey conducted by Colog in October 2005.
- 3) RQD = Rock Quality Designation

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BEDROCK TRANSPORT EVALUATION

Sauget Area 1, Sauget and Cahokia, Illinois

ATTACHMENTS

Attachment J-1	Description of Field Procedures
Attachment J-2	Rock Classification Worksheets
Attachment J-3	Thin Section Analysis Reports

BEDROCK TRANSPORT EVALUATION

Sauget Area 1, Sauget and Cahokia, Illinois

ATTACHMENT J-1 – DESCRIPTION OF FIELD PROCEDURES

Description of Field Procedures

*(Source: pages 125 to 138 from Volume 2 of Field Sampling Report,
O'Brien & Gere, September 2000)*

3.10. Bedrock Ground Water Sampling

3.10.1. Rationale/Design

As directed by USEPA Region V, three bedrock wells were installed in Sites G, H, and I in order to evaluate the vertical extent of organic and inorganic constituents migrating away from these sites. Locations for the bedrock wells were based on the shallow ground water concentration high plume estimated by Ecology and Environment (1998). Telescoping surface casings were installed in order to minimize carry-down of site-related constituents during ground water sample collection and vertical migration of site-related constituents after completion of sampling.

Bedrock was cored to a depth of 20 feet below the telescoping casing. Cores were digitally photographed (Section 3.10.4.6) in color against a scale and evaluated for porosity by examination and petrographic thin sections (Section 3.10.4.5). A ground water sample was collected from each core hole.

Number of Ground Water Samples	3
--------------------------------	---

Analyses:

Cyanide	USEPA Method 9010B
Dioxin	USEPA Method 8290
Herbicides	USEPA Method 8151A
Mercury	USEPA Method 7470A
Metals	USEPA Method 6010B
PCBs	USEPA Method 680
Pesticides	USEPA Method 8081A
SVOCs	USEPA Method 8270C
VOCs	USEPA Method 8260B

Sampling locations were selected in the field with the concurrence of USEPA Region V or its designee.

3.10.2. QA/QC Samples

QA/QC samples consisted of the following:

- one duplicate per 10, or fraction of 10, environmental samples collected
- one MS/MSD per 20, or fraction of 20, environmental samples collected or one MS/MSD every three working days, whichever was sooner

- one equipment blank (or field blank) per 10, or fraction of 10, environmental samples collected unless dedicated or disposable sampling equipment was used to collect samples
- one trip blank per sample cooler containing environmental samples for VOC analysis that was shipped.

QA/QC samples were submitted for analysis and analyzed for the same parameters as the investigative samples, as applicable. Duplicate samples were collected to measure consistency of field sampling technique. MS/MSD samples were collected to measure laboratory QC procedures. Equipment blanks were collected to measure the effectiveness of field decontamination procedures. Trip blanks were submitted to indicate cross-contamination of VOCs during shipment.

3.10.3. Field Procedures

Prior to performing field work, a Preparatory Inspection Meeting attended by a representative of each of the interested parties was held (meeting forms included as Section 3.10.4.2). Mud rotary drilling methods were used to drill the boreholes to set the telescoping casing and to drill five feet into the top of bedrock. Four change orders were implemented to enhance the bedrock sampling task:

1. Prevent/minimize drilling fluids from entering the four-inch casing
2. Redrill the four-inch casing at Site I due to upper bedrock zone
3. Install 18-inch casing at Site G to prevent/minimize loss of drill mud material
4. Extend eight-inch casing at Site G (Section 3.10.4.X).

Site G – Twenty-inch, temporary surface casing, approximately 10-feet below existing grade; 18-inch-ID casing set at 19 feet below existing grade to seal off large rubble in fill; 12-inch-ID casing set at 31.5 feet below existing grade, approximately five feet below fill; eight-inch-ID casing set at 71 feet below existing grade, approximately 45 feet below fill; four-inch-ID casing set at 112 feet below existing grade, approximately six feet into bedrock.

Site H – Twelve-inch-ID casing set at 31.5 feet below existing grade, approximately 5.5 feet below fill; eight-inch-ID casing set at 45.25 feet below grade, approximately 19 feet below fill; four-inch-ID casing set at 109.5 feet below existing grade, approximately 4.5 feet into bedrock.

Site I – Twelve-inch-ID casing set at 32.5 feet below existing grade, approximately 5.5 feet below fill; 12-inch-ID casing set at 53 feet below existing grade, approximately 26 feet below fill; four-inch-ID casing set

at 125.5 feet below existing grade, approximately 6.5 feet into bedrock. An upper rock layer was encountered at approximately 105 feet below existing grade. This rock layer was approximately 6.5 feet thick with loose sand below; hence, through review with Solutia representatives, the first four-inch casing was removed and reset at 125.5 feet.

Coring was accomplished using wireline coring barrels to generate a two-inch minimum core. Coring continued for 20 feet into the competent bedrock. Core samples were photographed (Section 3.10.4.6) and described on rock classification work sheets (Section 3.10.4.4). Descriptions followed the procedures outlined below. After coring was completed, a ground water sample was collected from the bedrock core hole. Sampling was accomplished using a Grundfos Rediflow™ pump, control box, and electrical generator. Sampling was accomplished following applicable procedures outlined in Section 3.7.3. A PID, four-gas meter, and a RAM were used to monitor these activities.

Once sample collection was completed, the pump and tubing were pulled. The tubing was placed into a plastic trash bag and disposed in the general waste dumpster. An expandable seal, locking plug was installed in the top of the four-inch casing. The borehole will be abandoned by filling the annular space with a cement and bentonite grout from bottom to top. The surface top two feet will be restored with soil and seeded. The drill rig was moved to the decontamination station and steam cleaned. Solids were placed into a container for transport to the Judith Lane storage site. Drilling fluids were contained in 55-gallon drums prior to disposal.

Sampling Equipment Decontamination –

- Brush-wash reusable sampling equipment in a bucket or tub using a trisodium phosphate (TSP) or other commercial detergent solution (two pounds of TSP per 10 gallons of clean water). Completely brush the entire exterior surface of the article undergoing decontamination. Wash interior wetted surfaces as required. Rinse the item with copious quantities of potable water, followed by a distilled water rinse.
- Rinse reusable sampling equipment used to collect environmental media for metals analysis in a dilute nitric acid solution, following by a distilled water rinse.
- Air-dry sampling equipment on a clean, nonplastic surface in a well-ventilated, uncontaminated environment. If the sampling device is not to be used immediately, wrap it in aluminum foil and place it in a plastic bag or storage container.
- Contain rinse waters in a plastic tub or bucket with a lid. Empty the contents of this tub daily into a 55-gallon drum located at the IDW storage area.

Decontamination waters were placed into a temporary container and transported to the wastewater disposal container. IDW, such as disposable gloves, paper towels, plastic sheeting, and Tyvek™ suits (if worn), were containerized and taken to the Judith Lane waste staging area prior to disposal.

Method – The geologists and geotechnical engineers wrote their description of rock samples with a consistent format. The order and presentation of selection of data are presented below.

The order in which the rock description was documented following the order presented below.

Order of Description for Lithology

1. Color	9. Weathering
2. Rock quality	10. Surface
3. Porosity	11. Hardness
4. Beds	12. Texture
5. Thickness	13. Grain shape
6. Contact	14. Sorting
7. Foliation	15. Mineral components
8. Joints	16. Rock classification

Abbreviations of the descriptions conformed to the standard abbreviation list. This list is presented below. A word that is not on this list was spelled out. An initial capital letter was used for each rock type. Capital letters are for formation names and rock types.

Punctuation was also standardized. The following convention was used for punctuation:

- comma after each item of description
- semicolon between each rock-type description
- no full stops (periods)

In addition, remarks such as A/A ("as above"), *same as above*, *see above*, or *same* are undesirable.

Log Order of Presentation and Selection – The following order was used to present information on the log:

1. **Color**
Color (from Munsell Color Chart) of logged interval or mass (sample).
2. **Rock Quality**
The rock quality designation (%RQD) is computed in the following way:

$$\%RQD = 100 \times \frac{[\text{length of core in pieces} \geq 4'] + [\text{hole length drilled or attempted (cored)}]}{[\text{hole length drilled or attempted (cored)}]}$$

Guidelines:

Measure from the center of natural breaks.

- Exclude joints that dip within five degrees of core axis.
- Exclude drill breaks. (See criteria for identification of drill breaks.)
- Do not calculate RQD for soft semi-indurate rock or severely weathered rock. ("Weathering" is addressed below.)

Scale:

90 - 100	Excellent	Massive
75 - 90	Good	Lightly fractured
50 - 75	Fair.....	Moderately fractured
25 - 50	Poor	Highly fractured
0 - 25	Very poor	Sheared

It is appropriate to think of RQD in conditions of equal effect; that is, group the RQD ranges as equivalent to rock type, structural domain, shear zones, and so forth.

Criteria for Identifying Drilling Breaks:

- A rough, brittle surface with fresh cleavage planes in individual rock minerals indicates an artificial fracture.
- A generally smooth or somewhat weathered surface with soft coating or infilling materials such as talc, gypsum, chlorite, mica, or calcite obviously indicates a natural discontinuity.
- In rocks showing foliation, cleavage, or bedding, it may be difficult to distinguish between natural discontinuities and artificial fractures when these are parallel with the incipient planes of weakness. If drilling has been carried out carefully, then the questionable breaks should be counted as natural features to make the conservative assumption.
- Depending on the drilling equipment, part of the length of core being drilled may occasionally rotate with the inner barrels in such a way that grinding of the surfaces of discontinuities and fractures occurs. In weak rock

types, it may be difficult to decide if the resulting rounded surfaces are present natural or artificial features. When in doubt, the conservative assumption should be made; that is, assume that they are natural.

- It is appropriate to keep a separate record of the frequency of artificial fractures for assessing the possible influence of blasting on the weaker sedimentary and foliated or schistose metamorphic rocks.

The occurrence of impurities is qualified with the following terms:

- consolidated, unconsolidated, semi-consolidated round, sub-round, sub-angular, angular, ellipsoidal, spherical.

Masses	Brecciated	Trace remnants
Pockets	Chaotically intermixed	Disseminated throughout matrix
Nodules	Fine wispy layers	Scattered
Blebs	Stringers	Streaks or specks
Lenses	Subtle network	Narrow zones
Oolites	Chicken wire pattern	
Zones	Dendritic	
Transitions		

3. Porosity

Use the following descriptions:

- none, medium, moderate, very, pinhole porosity, visual porosity.

4. Beds

Bedding, horizontal or inclined:

- planar
- mylonitic
- folded
- contorted
- wavy banding.

Bedding, beds, cleavage, and foliation:

Very thin	1 – 3 cm (0.4 - 1")
Thin	3 – 10 cm (1 - 4")
Medium	10 - 30 cm (4" - 1')
Thick	30 - 100 cm (1' - 3')
Very thick	>100 cm (>3')

Lamina:

- laminated: 0.3 – 1 cm (0.4 – 0.1")
- thinly laminated: <0.3 cm (<0.4")

5. **Thickness, Laminations, Lamella, Seams**

- smooth
- broken
- irregular
- convoluted
- up/down criteria

6. **Contact**

- distinct
- vague
- gradational

7. **Foliation**

- fissile (planar splitting)
- nonfissile

8. **Joints**

Planar	Irregular break	Infilled with
Parting	Scalloped	Healed fracture
Planes	Conchoidal	Mylonitic

Spacing:

Very thin	1 – 3 cm (0.4 - 1")
Thin	3 – 10 cm (1 - 4")
Medium	10 - 30 cm (4" - 1")
Thick	30 - 100 cm (1' - 3')
Very thick	>100 cm (>3')

9. **Weathering**

Fresh	Rock fresh; crystals or grains bright; a few joints may show slight staining; crystalline rocks ring if struck with a hammer.
Slight	Rock generally fresh; joints stained and may show clay filling if open; staining may extend into rock fabric adjacent to weathered planes; if present, feldspars may be dull and discolored; crystalline rocks ring if struck with hammer.
Moderate	Except for quartz, most of the rock mass shows discoloration and weathering; most feldspar is dull and discolored and kaolinitization

		(alteration to clay minerals) is common; rock gives a dull sound if struck with hammer; rock shows overall loss of strength; portions may be removed with a geologist's pick.
	Severe	All minerals except quartz discolored or stained; rock fabric still discernible; intergranular or intercrystalline disassociation virtually complete; internal structure essentially that of soil; fragments of strong rock may remain; may be called saprolite.
	Complete	Rock is decomposed to a soil; fabric not discernible or only barely discernible; quartz may remain as dikes or stringers.
10.	Surface Solid	Contains no voids.
	Pitted	Small voids generally restricted to joint surfaces, bedding planes, or other surfaces which provide access for attacking fluids.
	Vuggy	Use restricted to solution voids in carbonate rocks and hydrothermally altered rocks; voids may be found throughout the rock face; voids up to nine-inch diameter.
	Vesicular	Use restricted to voids in igneous (occasionally metamorphic) rocks, void origin usually due to gas bubbles; voids up to three-inch average diameter.
	Cavernous	Applicable in any rock; voids and channels greater than nine-inch average diameter; voids large enough to cause serious leakage or structural problems.
11.	Hardness	The following scale (not to be confused with Moh's scale for hardness of minerals) is used to a rock:
	Very Hard	Cannot be scratched with knife or sharp pick; breaking of hand specimens require several hard blows of geologist's pick.
	Hard	Can be scratched with knife or pick only with difficulty; hard blow of hammer required to detach hand specimen.
	Moderately	Can be scratched with knife or pick; gouges or groves to 1/8 inch deep can be excavated by

hard blow of point of geologist's pick; hand specimens can be detached by moderate blow.

Medium Can be grooved or gouged 1/16 inch deep by firm pressure on knife or pick point; can be excavated in small chips to pieces about one inch maximum size by hard blows of the point of a geologist's pick.

Soft Can be gouged or grooved readily with knife or pick point; can be excavated in chips to pieces several inches in size by moderate blows of a pick point; small thin pieces can be broken by finger pressure.

Very Soft Can be carved with knife; can be excavated readily with point of pick; pieces one inch or more in thickness can be broken by finger pressure; can be scratched readily by fingernail.

12. Texture

American Geological Institute data sheets:

- fine = <1 mm
- medium = 1.5 mm
- coarse = >5 mm

13. Grain Shape

very angular

- angular
- subangular
- subrounded
- rounded
- well-rounded

14. Sorting (For Sedimentary Rocks)

very well sorted

- well sorted (poorly graded)
- moderately sorted
- poorly sorted (well graded)
- very poorly sorted

15. Mineral Components

16. Rock Classification

American Geological Institute data sheets:

Accepted Abbreviations –

A

about.....ABT
 above.....ABV
 abundant.....ABDT
 accumulation.....ACCUM
 acicular.....ACIC
 aggregate.....AGG
 agglomerate.....AGLM
 algae.....ALG
 altered.....ALT
 amorphous.....AMOR
 amount.....AMT
 angular.....ANG
 anhedral.....ANHED
 anhydrite.....ANHY
 anhydritic.....ANHYDRIC
 apparent.....APR
 appears.....APRS
 approximate.....APROX
 aragonite.....ARAG
 arenaceous.....AREN
 argillaceous.....ARG
 arkose.....ARK
 asphalt.....ASPH
 at.....@
 average.....AV

B

band.....BND
 banded.....BNDD
 barite.....BAR
 basalt.....BAS
 bed.....BED
 bedded.....BEDD
 bedding.....BEDG
 bentonite.....BENT
 biotite.....BIOT
 bitumen.....BIT
 black.....BLK
 bleeding.....BLDG
 blocky.....BLKY
 botryoida.....BTRI
 bottom.....BTM
 boulder.....BLDR
 brachiopod.....BRAC
 breccia.....BREC
 brittle.....BRIT
 bright.....BRI
 broken.....BRKN
 brown.....BRN
 bryozoa.....BRY

C

calcite.....CA
 calcareous.....CALC
 carbonaceous.....CARB
 cavernous.....CAV
 caving.....CVG
 cement.....CMT
 center.....CNTR
 cephalopod.....CEPH

chalcedony.....CHAL
 chalk.....CHK
 chert.....CHT
 chitin.....CHIT
 chlorite.....CHL
 chloritic.....CHLTC
 clastic.....CLAS
 clay.....CLY
 claystone.....CLYST
 clean.....CLN
 clear.....CLR
 cleavage.....CLV
 cluster.....CLS
 coal.....COAL
 coarse.....C
 cobble.....CBL
 color.....COL
 common.....COM
 compact.....COMP
 conchoidal.....CONCH
 concentric.....CNCN
 conodont.....CONO
 conglomerate.....CGL
 contact.....CONT
 contorted.....CONTRT
 coquina.....COQ
 covered.....COV
 cream.....CRM
 crenelated.....CREN
 crevice.....CREV
 crinkled.....CRNK
 crinoid.....CRIN
 crossbedded.....XBEDD
 crosslaminated.....XLAM
 cross-stratified.....XSTRAT
 cryptocrystalline.....CRPXLN
 cryptograined.....CRPGR
 crystal.....XL
 crystalline.....XLN
 cuttings.....CTGS

D

dark.....DK
 dead.....DD
 debris.....DEB
 degree.....DEGR
 dendritic.....DEND
 dense.....DNS
 determine.....DTRM
 detrital.....DTRL
 diameter.....DIAM
 diatoms.....DIAT
 difference.....DIF
 disseminated.....DISM
 dolocast.....DOLC
 dolomite.....DOL
 dolomitic.....DOLIC
 dolomoid.....DOLM
 drusey.....DRSY

E

earthy.....ETHY
 echinoid.....ECH
 elliptical.....ELIP
 elongate.....ELNG
 embedded.....EMBEDD
 enlarged.....ENL
 epidote.....EP
 equivalent.....EQUIV
 euohedral.....EUHED
 evaporitic.....EVAP
 expose.....EXP
 extrusive.....EXTRU

F

faceted.....FAC
 faint.....FNT
 fair.....R
 fault.....FLT
 fauna.....FAU
 feldspar.....FELS
 ferruginous.....FE
 fibrous.....FIB
 figured.....FIG
 fine,-ly.....F
 fissile.....FISS
 flaggy.....FLGY
 flake,-y.....FLK,-Y
 flinty.....FLTY
 floating.....FLTG
 fluorescence.....FLUOR
 foliated, -ion.....FOL
 foraminifera.....FORAM
 formation.....FMTN
 fossil.....FOSS
 fossiliferous.....FOSSIF
 fracture,-ed.....FRAC
 fragment.....FRAG
 fresh.....FRSH
 friable.....FRI
 frosted.....FROS
 fusulinid.....FUS

G

gabbro.....GAB
 gastropod.....GAST
 glassy.....GL
 glauconite.....GLAUC
 globular.....GLOB
 gloss.....GLOS
 gneiss.....GN
 good.....G
 grade.....GRD
 grading.....GRDG
 grain.....GRN
 granite.....GRNT
 granular.....GRAN
 granule.....GRNL
 graptolite.....GRAP
 gravel.....GVL
 gray.....GRY
 graywacke.....GYWKE
 greasy.....GRSY

green.....GREEN
 gritty.....GRTY
 gypsum.....GYP
 gypsiferous.....GYPS

H

hard.....HD
 heavy.....HVV
 hematite.....HEM
 high.....HI
 horizontal.....HOR
 hornblende.....HBD
 hydrocarbon.....HYDC

I

igneous.....IG
 imbedded.....IMBEDD
 impregnated.....IMPRG
 impressions.....IMP
 included.....INCL
 inclusion.....INCLSN
 increase.....INCR
 indistinct.....IND
 interbedded.....INTBEDD
 intercrystalline.....INTXLN
 intergranular.....INTGRAN
 intergrown.....INTGWN
 interlaminated.....INTLAM
 interstitial.....INTSTL
 interval.....INTVL
 intraformational.....INTRM
 intrusion.....INTR
 invetebate.....INVRTB
 iron.....FE
 iron Oxides.....FE-OX
 ironstone.....FE-ST
 irregular.....IREG
 iridescent.....IRID

J

jasper.....JASP
 jointed.....JTD
 jointing.....JTG
 joints.....JTS

K

kaolin,-ite.....KAOL

L

laminated.....LAM
 large.....LRG
 lavender.....LAV
 layer.....LYR
 leached.....LCHD
 ledge.....LDG
 lenticular.....LENT
 light.....LT
 lignite.....LIG
 limestone.....LS
 limonite.....LMNT
 limy.....LMY
 lithic.....LITH
 lithographic.....LITHG

little LTL
long LONG
l OOSELSE
lower LOW
lumpy LMPY
luster LSTR

M

macro-fossil MACFOS
magnetic MAGN
magnetite MAG
marl ML
marlstone MRLST
maroon MAR
massive MASS
material MAT
matrix MTX
maximum MAX
medium M
member MBR
metamorphic METAM
mica MIC
micaceous MICAC
microcrystalline MICXLN
microfossil MICFOS
micrograined MICGR
micromicaceous MMIC
middle MID
mineral MNRL
minimum MIN
minor MNR
minute MNUT
moderate MOD
mollusca MOL
mottled MOT
mudstone MDST
muscovite MUSC

N

nacreous NAC
nodule NOD
numerous NUM

O

object OBJ
occasional OCC
ocher OCH
odor ODOR
oil OIL
olive OLV
oolitic OOL
opaque OPG
opposite OPP
orange ORNG
organic ORG
orthoclase ORTH
ostracod OST
oxidized OX

P

patchy PCHY
part PT
parting PTG

pearl PRL
pebble PBL
pegmatite PEG
pelecypod PLCY
pellet PEL
permeability PERM
petroleum PET
phosphate PHOS
pink PNK
pinpoint porosity PPP
pisolite PISO
pitted PIT
plagioclase PLAG
plant fossils PL FOS
plastic PLAS
platy PLTY
polish POL
poor PR
porcelaneous PORC
porosity POR
porphyry PORPH
possible POS
predominant PRED
preserved PRES
primary PRIM
prismatic PRIS
probably PROB
prominent PROM
pseudo PSDO
purple PURP
pyrite PYR
pyrobitumen PYRBIT
pyroclastic PYRCLAS

Q

quartz QTZ
quartzite QTZT
quartzitic QTZTC
quartzose QTZS

R

radiate RAD
range RNG
random RAND
rare RR
red R
regular REG
remains RMN
replaced RPL
residue RESD
resinous RSNS
rhombohedral RHMB-L
rock RK
round RND
rounded RNDD
rubbly RBLY
rusty RST

S

salt SALT
saccharoidal SACC
sample SMPL
sand SD

sandstone SS
 sandy SDY
 saturated SAT
 scales SC
 scarce SCS
 scattered SCAT
 schist SCH
 scolecondonts SCOL
 secondary SEC
 sediment SED
 selenite SEL
 sericite SER
 severe SEV
 shale, -ly SH, SHY
 siderite SID
 silica SIL
 siliceous SILIC
 silky SLKY
 slit SLT
 siltstone SLTST
 size SZ
 slickensided SLKS
 slight SL
 small S
 smooth SMTH
 soft SFT
 soluble SOLB
 solution SOL
 sort SRT
 speck SPCK
 sphalerite SPHAL
 spherules SPH
 spicule SPIC
 splintery SPL
 sponge SPG
 spore SPR
 spot SP
 stain STN
 stained STND
 staining STNG
 stippled STIP
 strata STRAT
 streak STR
 striated STRI
 stringer STRG
 stromatoparoids ... STROM
 structure STRUC
 stylolite STYL
 subangular SUBANG
 subhedral SUBHED
 sucrose SUC

sulphur SULF
 surface SURF

T
 tabular TAB
 texture TEX
 thick THK
 thin THN
 through THRU
 tight TT
 tourmaline TOUR
 trace TR
 transparent TRNSP
 trilobite TRILO
 tripolitic TRIP
 tubular TUB
 tuff TUFF

U
 unconformity UNCONF
 unconsolidated... UNCONS
 upper UP

V
 variable VAR
 varicolored VCOL
 variegated VGTD
 varved VRVD
 vein VN
 vertebrate VRTB
 very V
 vesicular VES
 vitreous VIT
 volcanics VOLC
 vug, -gy, -ular VUG

W
 water WTR
 wavy WAVY
 waxy WXY
 weather WTHR
 weathered WTHRD
 white WH
 with W/

Y
 yellow YEL

Z
 zone ZN

3.10.4. Documentation

Four change orders are included in Section 3.10.4.1. Field logs generated are included in Record Book No. 1 (Appendix D). Figure 1 depicts bedrock ground water sampling locations. Ground water sampling logs are included in Section 3.10.4.3. Rock classification work sheets are included in Section 3.10.4.4. A petrographic thin section report is included in Section 3.10.4.5. Digital photographs of rock cores are included in Section 3.10.4.6. Chain-of-custody forms are included in Section 3.10.4.7.

Documentation for this task continues on the next page.

GSI Job No. G-2876
Issued: August 28, 2006



BEDROCK TRANSPORT EVALUATION

Sauget Area 1, Sauget and Cahokia, Illinois

ATTACHMENT J-2 – ROCK CLASSIFICATION WORKSHEETS

Rock Classification Worksheets

(Source: pages 145A-1 to 145A-75 from Volume 2 of Field Sampling Report, O'Brien & Gere, September 2000)

Sauget Area 1

Rock Classification worksheet

Site 4 piece #1; 20xg 112-113.67

Color: light gray

Rock Quality: excellent, massive

Porosity: none

Beds: planar, wavy, block

Thickness: 20 inches

Contact: distinct

Foliation: planar

Joints: faint filled fracture line, a surface line at bottom

Weathering: exhibited at bottom, black sand pitted

Surface: solid

Hardness: moderate to hard

Texture: microgranular

Grain Shape: rounded

Sorting: well sorted

Mineral components: ~~white calcite~~ has some white calcite?

Rock Classification: limestone

Sauget Area 1

Rock Classification worksheet

Site 1 piece 2, 8.25 inches, 113.67-114.36

Color: light gray, NT

Rock Quality: excellent, medium

Porosity: none

Beds: planar, ~~medium~~ medium

Thickness: 8.25 inches

Contact: distinct

Foliation: planar

Joints: suture line at top; clay filled (insufficient at bottom)

Weathering: along joints

Surface: smooth

Hardness: moderate to hard

Texture: granular, very fine to medium

Grain Shape: rounded

Sorting: well sorted

Mineral components: decomposed, white specks (calcite)

Rock Classification: limestone

Sauget Area 1

Rock Classification worksheet

Lites & piece 3, 17.5 inches, 114-36-115.82

Color: *light grey*

Rock Quality: *excellent*

Porosity: *None*

Beds: *planar, thick*

Thickness: *very thick 17.5*

Contact: *distinct*

Foliation: *planar*

Joints: *fine, filled fractures at top end for $\approx 1/2$ inch, thick at bottom, clay filled, fracture at 14 inches has a rough pitted surface*

Weathering: *subdued at top & bottom*

Surface: *solid*

Hardness: *moderate to hard*

Texture: *granular to crystalline, very fine to medium*

Grain Shape: *rounded to subrounded*

Sorting: *well sorted*

Mineral components: *less than white calcite!*

Rock Classification: *limestone*

Sauget Area 1

Rock Classification worksheet

Site 11, Loc 4; 8.5 in, 11582-11653

Color: *light gray*

Rock Quality: *excellent, massive*

Porosity: *none*

Beds: *planar, ~~very thick~~ medium*

Thickness: *8.5 inches*

Contact: *distinct*

Foliation: *planar*

Joints: *fine fine filled fractures at top and bottom, clay filled; one near vertical fracture in middle*

Weathering: *exhibited in fractures*

Surface: *solid*

Hardness: *moderate to hard*

Texture: *very fine to microgranular*

Grain Shape: *rounded to subrounded*

Sorting: *well sorted*

Mineral components: *none observed*

Rock Classification: *limestone*

Sauget Area 1

Rock Classification worksheet

Section 1, piece #5, 5.75 in., 116.53-117.03

Color: light gray

Rock Quality: excellent, massive

Porosity: none

Beds: planar, ~~very thick~~ medium

Thickness: 5.75 inches

Contact: distinct

Foliation: planar

Joints: one, nearly vertical from top to bottom

Weathering: pitted dark gray surface at top and bottom, vertical fracture, slightly stained, somewhat chert

Surface: solid

Hardness: moderate to hard

Texture: very fine to med. granular / crystalline

Grain Shape: rounded to sub-rounded

Sorting: well sorted

Mineral components: calcite

Rock Classification: limestone

Sauget Area 1

Rock Classification worksheet

Site # piece #6, 1 1/2 inches, 117.03-118-36

Color: light gray

Rock Quality: excellent, massive

Porosity: none

Beds: planes, very thick

Thickness: 11 inches

Contact: distinct

Foliation: plane

Joints: horizontal fine lines: 2.5 inches from top and bottom

Weathering: slight, exhibited at top and bottom, but mostly solid

Surface: solid

Hardness: moderate to hard

Texture: ~~very~~ fine to medium

Grain Shape: subrounded, angular crystals

Sorting: well sorted

Mineral components: calcite?

Rock Classification: limestone

Sauget Area 1

Rock Classification worksheet

Silex piece 7, 3 inches, 118.36-118.51 (to porous, ly)

Color: light gray

Rock Quality: excellent, massive

Porosity: none

Beds: planar, very thick then

Thickness: 3 inches

Contact: distinct

Foliation: planar

Joints: Horizontal to nearly horizontal filled fractures

Weathering: exhibited at top and bottom as pitted, rough surfaces

Surface: solid

Hardness: moderate to hard

Texture: very fine to medium granular

Grain Shape: subrounded

Sorting: well sorted

Mineral components: some calcite

Rock Classification: limestone

Sauget Area 1	
Rock Classification worksheet	
Site: 4, piece 8, 11 inches, 118.51-119.43	
Color:	light gray
Rock Quality:	excellent, massive
Porosity:	none
Beds:	planar, very thick medium
Thickness:	11 inches
Contact:	distinct
Foliation:	planar
Joints:	horizontal, wavy filled fractures, some 45° angle, fractured at bottom, dark gray rough pitted surface
Weathering:	slight to moderate along fractures
Surface:	smooth
Hardness:	moderate to hard
Texture:	very fine to micro granular
Grain Shape:	subrounded, crystals angular
Sorting:	well sorted
Mineral components:	calcite present as small crystals
Rock Classification:	limestone

Sauget Area 1

Rock Classification worksheet

Site 4 piece #9, 119.43 - 120.56

Color: light gray

Rock Quality: excellent

Porosity: none

Beds: planar, thick

Thickness: 13.5 cm thick

Contact: distinct

Foliation: planar (generally horizontal clay filled fractures; occasional vertical healed fracture near top)

Joints:

Weathering: exhibited in fractures, and at top and bottom

Surface: smooth

Hardness: moderate to hard

Texture: very fine to medium grained, some crystallization at top

Grain Shape: subrounded, angular crystals

Sorting: well-sorted

Mineral components: calcite crystals

Rock Classification: limestone

Sauger Area 1

Rock Classification worksheet

Site # piece: 10, 130.56-131.12

Color: light gray

Rock Quality: excellent, massive

Porosity: none

Beds: planar, very thick-medium

Thickness: 6.75 inches

Contact: distinct

Foliation: planar

Joints: wavy horizontal clay filled joints
of fracture near bottom

Weathering: exhibited at top and bottom in clay filled fractures

Surface: solid

Hardness: moderate to hard

Texture: fine to medium grained, some crystallization

Grain Shape: subrounded to sub-angular

Sorting: well sorted

Mineral components: at disseminated white specks (calcite?)

Rock Classification: limestone

Sauget Area 1

Rock Classification worksheet

Site 1, piece 11, 1.5 inches 121.12 - 121.76

Color: light gray

Rock Quality: excellent, massive

Porosity: none

Beds: planar, may be medium

Thickness: 1.5 inches

Contact: distinct

Foliation: planar

Joints: near horizontal wave fracture lines at top?

Weathering: exhibited as clay seams at top and bottom pitted at bottom

Surface: solid

Hardness: moderate to hard

Texture: very fine to medium grained some crystallization

Grain Shape: rounded to subrounded

Sorting: well sorted

Mineral components: with calcite

Rock Classification: limestone

Sauget Area 1

Rock Classification worksheet

Siliceous piece 12-18.5 in 122-122.71 (porosity)

Color: *1 light gray*

Rock Quality: *fair*

Porosity: *none*

Beds: *planar, very thick medium*

Thickness: *8.5 in*

Contact: *distinct*

Foliation: *planar*

Joints: *Horizontal and vertical fracture lines*

Weathering: *slight at top & bottom*

Surface: *smooth*

Hardness: *moderate to hard*

Texture: *very fine to microcrystalline*

Grain Shape: *rounded*

Sorting: *well sorted*

Mineral components: *some calcite*

Rock Classification: *limestone*

Sauget Area 1

Rock Classification worksheet

Site 4, piece 13, 122.71 - 123.31

Color: light gray

Rock Quality: fair

Porosity: none

Beds: planar, medium

Thickness: 7.25

Contact: distinct

Foliation: foliation

Joints: horizontal wavy fracture

Weathering: slight at top and bottom

Surface:

Hardness: moderate to hard

Texture: very fine to microgranular

Grain Shape: rounded to subrounded

Sorting: well sorted

Mineral components: a few white spots

Rock Classification: limestone

Sauget Area 1

Rock Classification worksheet

Site 4 piece 14, 3 in. 123.31-123.56

Color: light gray

Rock Quality: fair

Porosity: none

Beds: planar, very thin

Thickness: 3.0 inches

Contact: distinct

Foliation: planar

Joints: wavy, fine lines at bottom

Weathering: slight at top and bottom

Surface: solid

Hardness: ~~medium to hard~~

Texture: ~~very fine to~~ microgranular, flaky break
planar

Grain Shape: ~~subrounded~~

Sorting: well sorted

Mineral components: calcite

Rock Classification: limestone

Sauget Area 1

Rock Classification worksheet

Sample 4 piece 5 123.56 - 123.83 ft

Color: *light gray*

Rock Quality: *fair*

Porosity: *none*

Beds: *planar, thin*

Thickness: *3.25 inch, 1'*

Contact: *disconform*

Foliation: *planes*

Joints: *none*

Weathering: *slight cat to p*

Surface: *solid*

Hardness: *hard*

Texture: *microgranular*

Grain Shape: *subangular*

Sorting: *well-sorted*

Mineral components: *—*

Rock Classification: *limestone*

Sauget Area 1

Rock Classification worksheet

Libby piece 16, 123.83 - 124.46

Color: *light gray*

Rock Quality: *fair*

Porosity: *none*

Beds: *planar, medium*

Thickness: *7.5*

Contact: *distinct*

Foliation: *planar*

Joints: *none, present within, clay filled part bottom*

Weathering: *at bottom*

Surface: *solid*

Hardness: *hard*

Texture: *microgranular*

Grain Shape: *angular to subrounded, some darker gray specks and spots*

Sorting: *well sorted*

Mineral components: *calcite present*

Rock Classification: *limestone*

Sauget Area 1

Rock Classification worksheet

Section piece 17 *124.46-124.63*

Color: *light gray*

Rock Quality: *fair*

Porosity: *none*

Beds: *planar, thin*

Thickness: *2 inches*

Contact:

Foliation: *planar*

Joints: *wavy, horizontal; one clay filled fracture*

Weathering: *along clay filled fracture at top*

Surface: *solid*

Hardness: *moderate to hard*

Texture: *micro granular, to*

Grain Shape: *not rounded to subrounded*

Sorting: *well sorted*

Mineral components: *calcite*

Rock Classification: *limestone*

Sauget Area 1

Rock Classification worksheet

Q154 piece section 18 120.63 - 125.30

Color: *light gray*

Rock Quality: *fine*

Porosity: *none*

Beds: *planar, thin to thick*

Thickness: *2-8" in total, 11+ pieces*

Contact: *dissect*

Foliation: *planar*

Joints: *wavy fractures*

Weathering: *none*

Surface: *solid*

Hardness: *moderate to hard*

Texture: *medium granular*

Grain Shape: *angular*

Sorting: *well sorted*

Mineral components: *—*

Rock Classification: *limestone*

Sauget Area 1

Rock Classification worksheet

Site 2, piece 19 125.30 to 125.45

Color: light gray

Rock Quality: fair

Porosity: none

Beds: planar, ~~fine~~ thin

Thickness: 1.75 inches

Contact: distinct

Foliation: planar

Joints: healed vertical fracture

Weathering: none observed

Surface: solid

Hardness: moderate to hard

Texture: micro granular

Grain Shape: rounded

Sorting: well sorted

Mineral components: —

Rock Classification: limestone

Sauger Area 1

Rock Classification worksheet

Site 4, piece 20, 125.45-125.76

Color: light gray

Rock Quality: fine

Porosity: none

Beds: planar, then

Thickness: 3.75 inches

Contact: disconformity

Foliation: planar

Joints: generally horizontal many filled fractures
one healed fracture at 45° X;

Weathering: ent top, clayey

Surface: solid

Hardness: moderate to hard

Texture: micro

Grain Shape: —

Sorting: —

Mineral components: —

Rock Classification: limestone

Sauget Area 1

Rock Classification worksheet

Site 2, piece 1 125.76 - 125.91

Color: light gray

Rock Quality: fair

Porosity: none

Beds: planar thick thin

Thickness: 1.75

Contact: distinct

Foliation: planar

Joints: none observed

Weathering: top + bottom, slight

Surface: solid

Hardness: mod to hard

Texture: micro granular

Grain Shape:

Sorting:

Mineral components: fcr

Rock Classification: limestone

Sauget Area 1

Rock Classification worksheet

Q12 (2), sites 22 thru 25 12591-12632

Color: light gray

Rock Quality: fair

Porosity: none

Beds: thick planar, medium

Thickness: 4.9 inches

Contact: distinct

Foliation: planar

Joints: wavy line lines, clay filled

Weathering: exhibited along fractures

Surface: solid

Hardness: 1 max. - hard

Texture: medium grained

Grain Shape: —

Sorting: —

Mineral components: —

Rock Classification: limestone

Sauger Area 1

Rock Classification worksheet

Lat: 21 piece 26 126.32-1 126.62

Color: light gray

Rock Quality: fair

Porosity: none

Beds: planar, thin

Thickness: 3.625 in.

Contact: distinct

Foliation: planar

Joints: Horizontal joint line fracture, 2 healed vertical fractures

Weathering: a slight at top & bottom

Surface: smooth

Hardness: mod - hard

Texture: microgranular

Grain Shape: —

Sorting: —

Mineral components: clay in fractures

Rock Classification: limestone

Sauget Area 1

Rock Classification worksheet

Site H piece 27 124.62 - 126.79

Color: light gray

Rock Quality: fair

Porosity: none

Beds: planar, thin

Thickness: 2 inches

Contact: distinct

Foliation: planar

Joints: clay filled fractures at top + bottom

Weathering: top and bottom

Surface: smooth

Hardness: mod - hard

Texture: microgranular

Grain Shape: —

Sorting: —

Mineral components: —

Rock Classification: limestone

Sauget Area 1

Rock Classification worksheet

Site # 1, p. 28, 126.79 - 128.17 (2814, porosity)

Color: light gray

Rock Quality: fair

Porosity: none

Beds: planar, ~~thin~~ thick

Thickness: 16.5 cm (16.5)

Contact: distinct

Foliation: planar

Joints: horizontal, irregular

Weathering: slight exhibited at top and bottom

Surface: smooth

Hardness: moderate to hard

Texture: micro

Grain Shape: --

Sorting: --

Mineral components: --

Rock Classification: limestone

Sauger Area 1

Rock Classification worksheet

Site #1 piece 29 128.17-129.09

Color: light gray

Rock Quality: fair

Porosity: none

Beds: planar, medium

Thickness: 11.0 inches

Contact: distinct

Foliation: planar

Joints: horizontal wavy, fine fractures, clay filled

Weathering: slight at top & bottom

Surface: solid

Hardness: 1.5

Texture: micro granular

Grain Shape: —

Sorting: —

Mineral components: some white specks

Rock Classification: limestone

128.17-129.09
128.17-129.09

Sauget Area 1

Rock Classification worksheet

Site 21, piece 30, 129.09 - 130.46

Color: light gray

Rock Quality: fair

Porosity: none

Beds: planar, ~~very~~ thick

Thickness: 16.5 inches, 1

Contact: distinct

Foliation: planar

Joints: many fine wavy, essentially horizontal
near top half present in bottom

Weathering: slight at top & bottom, bottom dark gray
and pitted

Surface: solid

Hardness: mod to hard

Texture: microgranular

Grain Shape: —

Sorting: —

Mineral components: —

Rock Classification: limestone

Sauget Area 1

Rock Classification worksheet

Site 31, 130.46 - 130.80

Color: light gray

Rock Quality: fair

Porosity: none

Beds: planar, ~~medium~~ medium

Thickness: 4.125

Contact: distinct

Foliation: planar

Joints: few horizontal lines

Weathering: dark gray pitted clay at top

Surface: solid

Hardness: mod to hard

Texture: med granular

Grain Shape:

Sorting:

Mineral components: quartz infilling one to fraction, calcite 34%
long to fine scale

Rock Classification: limestone

Sauget Area 1

Rock Classification worksheet

Site 4 piece 32. 130.80-131.34 Porosity
Color: light gray, some darker gray specks & splattered

Rock Quality: fair

Porosity: none

Beds: planar, ~~very~~ thick medium

Thickness: 6-5 inches

Contact: distinct

Foliation: planar

Joints: horizontal fine lines

Weathering: slight at bottom

Surface: solid

Hardness: mod to hard

Texture: microgranular

Grain Shape: ~

Sorting: —

Mineral components: —

Rock Classification: limestone

Sauget Area 1

Rock Classification worksheet

Section 133 131.34 - 131.51

Color: *light gray*

Rock Quality: *fair*

Porosity: *none*

Beds: *plana, ~~thin~~ thin*

Thickness: *2.0*

Contact: *distinct*

Foliation: *plana*

Joints: *horizontal fissure fractures*

Weathering: *slight at top + bottom*

Surface: *solid*

Hardness: *mod - hard*

Texture: *micro granular*

Grain Shape: *—*

Sorting: *—*

Mineral components: *some white outlines, fossils(?)*

Rock Classification: *limestone*

Sauget Area 1	Sit H
Rock Classification worksheet	
Piece #1 → 8, 111-112.5 feet Below Existing Grade (SEF)	
Color:	best fresh surface med. gray to med. light gray
Rock Quality:	3 1/2; poor, low
Porosity:	none
Beds:	subhorizontal, breaks along clay seams, ranges from 2-7 cm thick (very thin to thin), S
Thickness:	smooth
Contact:	very distinct between sections
Foliation:	has some white specks to pieces up to 1/2 long, rounded to blocky, may be calcite as they effervesce in HCL; polished horizontal to slightly wavy
Joints:	usually along horizontal liney clay seams, within section is stylolitic (wavy + chevron) perpendicular to them
Weathering:	fresh
Surface:	Solid; solution at surface, it is clay at 112.5 feet BGL
Hardness:	hard
Texture:	very fine (much less than 1 mm) micro, occasionally brachiopod fossil
Grain Shape:	matrix too fine to tell, some inclusions are rounded to very angular
Sorting:	generally very well sorted
Mineral components:	traces of black spec (hornblende), pyrite, possibly aragonite or calcite
Rock Classification:	limestone; some shell fossils

Sauget Area 1	
Rock Classification worksheet <i>Site H</i>	
<i>piece #9, H-5 - 15.75 inches long, 112.5-113.81</i>	
Color:	<i>dry - N7, light gray</i> <i>wet - N7, light gray</i>
Rock Quality:	<i>massive</i>
Porosity:	<i>porous</i>
Beds:	<i>one bed 15+ inches thick, planar</i>
Thickness:	<i>15.75 inches</i>
Contact:	<i>upper - broken, rounded; lower - with striae</i> <i>distinct</i>
Foliation:	<i>planar</i>
Joints:	<i>Schistosity at $\approx 60^\circ$ angle at top; striae upper 5 inches</i> <i>and lower 3/4 of section</i>
Weathering:	<i>slight at both ends</i>
Surface:	<i>solid</i>
Hardness:	<i>hard</i>
Texture:	<i>microporous to crystalline coarse brick pebbles</i>
Grain Shape:	<i>rounded, ≈ 0.2 mm or less</i>
Sorting:	<i>well sorted</i>
Mineral components:	<i>disseminated calcite? with limestone matrix</i> <i>some</i>
Rock Classification:	<i>limestone</i>

Sauget Area 1	Site H
Rock Classification worksheet	
Piece 10;	~12" long, 113.81 - 114.81
Color:	N7. light gray
Rock Quality:	massive
Porosity:	none
Beds:	one bed planar, medium-thick
Thickness:	~12 inches
Contact:	distinct
Foliation:	planar
Joints:	waviness starting at 7" below top and continuing to bottom, generally linear but up to 2mm, darker gray
Weathering:	none, slight at top and bottom
Surface:	solid
Hardness:	hard
Texture:	microgranular; some brachiopod fossils
Grain Shape:	rounded
Sorting:	well sorted
Mineral components:	luminated calcite?, some b
Rock Classification:	limestone

Sauget Area 1 *Set H*
Rock Classification worksheet

piece 11; 36 inches; 114.81 - 117.81

Color: *top 15.5" med. light gray Nli; light gray 15.5 to 26.75; med gray 26.75 - 36 inches*

Rock Quality: *massive*

Porosity: *none*

Beds: *planar, wavy + thick; wavy lines*

Thickness: *36 inches*

Contact: *distinct*

Foliation: *planar + wavy*

Joints: *very wavy, strike, nearly vertical at top; horizontal base line strikes from top*

Weathering: *top + bottom exposed*

Surface: *solid*

Hardness: *Hard*

Texture: *microgranular*

Grain Shape: *rounded*

Sorting: *well sorted*

Mineral components: *disseminated white calcite? some are thin black metallic line at 15.75 in. from top*

Rock Classification: *limestone (breaks through grains at top, around grains at bottom) gneiss*

Sauget Area 1 Site H
Rock Classification worksheet

piece 12, 10.75 inches; ±17.81 to ±18.81

Color: light gray

Rock Quality: massive

Porosity: none

Beds: one, flaser, medium

Thickness: 10.75 inches

Contact: distinct

Foliation: fine

Joints: irregular break

Weathering: fine slight at top and bottom

Surface: solid

Hardness: ps. Hard

Texture: macrocrystalline, occasional brachiopod shell
imprints

Grain Shape: rounded

Sorting: well sorted

Mineral components: approximately 1/2 inch wide band at bottom
contains full black specks; 3mm wide blue green heavy band @ ±7.5" from top

Rock Classification: limestone

Sauget Area 1 Site H
Rock Classification worksheet

Piece #13, ~~3.25~~ 3.25" ; 118.81 to 119.10

Color: light gray, N 7

Rock Quality: massive

Porosity: none

Beds: planar, ~~that very thick~~ thin

Thickness: ~~3.25 inches~~ 3.25 in

Contact: distinct

Foliation: a few wavy lines

Joints: planar

Weathering: slight

Surface: smooth

Hardness: hard

Texture: microgranular

Grain Shape: rounded

Sorting: well sorted

Mineral components: none

Rock Classification: limestone

Sauget Area 1 *Site H*
Rock Classification worksheet

piece #14: 14.5 inches long; 119.10 to ~~119.10~~ 120.31

Color: *light gray, N 6;*

Rock Quality: *massive*

Porosity: *none*

Beds: *planar, very thick*

Thickness: *14.5 inches*

Contact: *distinct*

Foliation: *wavy lines near top and at bottom; may
clay filled*

Joints: *planar, wavy, clay filled*

Weathering: *slight at top & bottom*

Surface: *solid*

Hardness: *Hard*

Texture: *medium grained*

Grain Shape: *rounded*

Sorting: *well sorted*

Mineral components: *~~some plagioclase~~ disseminated white calcite
crystals; green specks + streaks*

Rock Classification: *Gneiss*

Sauget Area 1

Rock Classification worksheet

Site # area 15; 3.75 inches; 120.31-120.62

Color: light gray, N7

Rock Quality: massive

Porosity: none

Beds: planes, very thin & thin

Thickness: 3.75 inches

Contact: distinct

Foliation: wavy, horizontal to nearly vertical

Joints: top & bottom

Weathering: at top & bottom

Surface: solid

Hardness: hard

Texture: microgranular

Grain Shape: rounded

Sorting: well sorted

Mineral components: minor silicate?

Rock Classification: limestone

Sauget Area 1

Rock Classification worksheet

Silt H, piece #16, 5.625 in., 120.62-121.10

Color: light gray

Rock Quality: massive

Porosity: none

Beds: planar, thin

Thickness: 2-3 inches

Contact: clustered

Foliation: wavy planar

Joints: wavy

Weathering: at top & bottom

Surface: smooth

Hardness: moderate to hard

Texture: microgranular

Grain Shape: rounded to subrounded

Sorting: well sorted

Mineral components: calcite? as rounded 1/2 nodules; ~~carbon~~

Rock Classification: limestone

Sauget Area 1

Rock Classification worksheet

Site H, piece 17: 10 inches, 121.10 to 121.93

Color: light gray

Rock Quality: medium

Porosity: none

Beds: planar, very thin to medium

Thickness: 10 inches

Contact: distinct

Foliation: horizontal, wavy

Joints: planar

Weathering: at top & bottom

Surface: solid

Hardness: moderate to hard

Texture: microgranular

Grain Shape: rounded

Sorting: well sorted

Mineral components: calcite and rounded $\frac{1}{2}$ nodules

Rock Classification: limestone

6/5

Sauget Area 1	Sitoh
Rock Classification worksheet	
Sitoh piece 18, 122.5 - 123.13	
Color:	light gray, N7
Rock Quality:	excellent, massive
Porosity:	none
Beds:	plane, very thick medium
Thickness:	10 inches
Contact:	distinct
Foliation:	plane
Joints:	vertical to inclined planes, filled with clay
Weathering:	fine, light , top and bottom are slightly pitted and clayey
Surface:	solid
Hardness:	hard
Texture:	very fine to micro, flaky has on broken surfaces some brachiopod shell impressions
Grain Shape:	rounded
Sorting:	well sorted
Mineral components:	none observed
Rock Classification:	limestone

Sauget Area 1

Rock Classification worksheet

Site H, piece 19: 15.5 inches	123.13 - 124.42 123.13 - 124.42
Color:	light gray, N7
Rock Quality:	excellent, massive
Porosity:	none
Beds:	planar, very thick
Thickness:	15.5 inches
Contact:	distinct
Foliation:	planar; fine ^{very} bedded throughout length, clay filled
Joints:	fine, wavy, clay filled horizontal to angular inclined planes; stylolites occasionally
Weathering:	slight to fresh; top and bottom exhibit pitted clayey surface
Surface:	solid
Hardness:	moderate to hard
Texture:	microgranular < 1 mm
Grain Shape:	rounded to subrounded
Sorting:	well sorted
Mineral components:	none additional observed
Rock Classification:	limestone

Sauget Area 1	
Rock Classification worksheet	
Site H: piece 20, 10 inches:	124.92-125.05
Color:	1 light gray, N7
Rock Quality:	excellent, massive
Porosity:	none
Beds:	planar, very thick medium
Thickness:	10 inches
Contact:	distinct
Foliation:	planar
Joints:	few very filled fractures at top
Weathering:	disintegrated at top + bottom; partial clay filled fractures
Surface:	solid
Hardness:	moderate to hard
Texture:	very fine to microgranular
Grain Shape:	rounded
Sorting:	well sorted
Mineral components:	solid a few white calcite?
Rock Classification:	limestone

Sauget Area 1

Rock Classification worksheet

Left H, piece 21, 29.5 inches; 125.05-127.51
~~135.05-137.51~~

Color: light gray, A17

Rock Quality: excellent, massive

Porosity: none, except in rock, possibly in thin fractures

Beds: planar, ~~very~~ thick

Thickness: 29.5 inches

Contact: distinct

Foliation: planar

Joints: wavy lines in middle section and at lower end
possibly clay filled fractures, generally much darker
gray than bulk rock (sampled A17)

Weathering: only in fractures, top and bottom

Surface: solid

Hardness: moderate to hard

Texture: very fine to micro granular

Grain Shape: rounded

Sorting: well sorted

Mineral components: pyrite on one fracture line

Rock Classification: limestone

Sauget Area 1	
Rock Classification worksheet	
127.51 - 128.99	
Lith piece 22 - 17.75 inches 137.51 / 138.99	
Color:	light gray
Rock Quality:	excellent, massive
Porosity:	none except in fracture
Beds:	planar, thick
Thickness:	17.75
Contact:	distinct
Foliation:	planar
Joints:	several fracture lines, clay filled pyrite in fractures at 3 inches from bottom; black and pitted in middle fracture
Weathering:	none within; along larger fractures - slight
Surface:	smooth
Hardness:	moderate to hard
Texture:	granular, very fine to micro
Grain Shape:	rounded to subrounded, some XL's angular
Sorting:	well sorted
Mineral components:	calcite, pyrite in one fracture
Rock Classification:	limestone

Sauget Area 1

Rock Classification worksheet

QTH piece 23: 11 inches, 128.99 - 129.91
138.99 to 139.91

Color: light gray, NT

Rock Quality: excellent, medium

Porosity: none

Beds: planar, ~~fine to medium~~

Thickness: 11 inches

Contact: distinct

Foliation: planar

Joints: ~~waves from filled fractures at bottom and surfaces~~
dark gray clay filled

Weathering: along fracture lines

Surface: solid

Hardness: ~~hard~~ moderate to hard

Texture: granular; very fine to micro

Grain Shape: subrounded to ~~subangular~~ subangular

Sorting: well sorted

Mineral components: calcite

Rock Classification: limestone

Sauget Area 1

Rock Classification worksheet

Sitz H. piece 24 8.75 inches; 129.91 - 130.64
139.91 - 142.64

Color:

light gray

Rock Quality:

excellent medium

Porosity:

none

Beds:

planar, ~~very fine~~ ^{medium}, one thinned at bottom

Thickness:

8.75

Contact:

distinct

Foliation:

planar

Joints:

clay filled wavy planar fracture lines

Weathering:

exhibited in fractures

Surface:

solid

Hardness:

moderate to hard

Texture:

very fine to micro granular

Grain Shape:

rounded to subrounded

Sorting:

well sorted

Mineral components:

—

Rock Classification:

Amethyst

Sauget Area 1	
Rock Classification worksheet	
Site H - piece # 5 4.75 inches, 130.64 - 131.04 440.64 - 141.04	
Color:	light gray N7
Rock Quality:	massive
Porosity:	none
Beds:	planar, thin medium 5/8 inch thick
Thickness:	4.75 inches clay/shale layer at bottom
Contact:	distinct
Foliation:	planar
Joints:	wavy fine fracture lines
Weathering:	exhibited in clay filled fracture
Surface:	smooth
Hardness:	moderate to hard
Texture:	very fine to microgranular,
Grain Shape:	subrounded
Sorting:	well sorted
Mineral components:	calcite
Rock Classification:	limestone,

Sauget Area 1
Rock Classification worksheet

Site H

pieces 26427, 10 inches

131.04 - 131.87

141.04 - 141.87

primary

Color:

light gray

Rock Quality:

excellent, massive

Porosity:

none

Beds:

planar, ~~very thick~~ medium

Thickness:

10 inches

Contact:

distinct

Foliation:

planar

Joints:

none

Weathering:

exhibits at top in clay filled fractures

Surface:

solid

Hardness:

moderate to hard

Texture:

microgranular

Grain Shape:

rounded

Sorting:

well sorted

Mineral components:

—

Rock Classification:

limestone

Sauget Area 1

Rock Classification worksheet

Site I, 111-113 feet, 5 specimens

Color: very light gray, then light gray

Rock Quality: poor

Porosity: none

Beds: 1.5 to 3.75 inches planar thin to medium thick

Thickness: 1.5 to 3.75 inches

Contact: distinct

Foliation: planar

Joints: many fine lines nearly horizontal

Weathering: exhibited along fracture line

Surface: solid

Hardness: mod to hard

Texture: very fine to micro granular

Grain Shape: rounded to subrounded

Sorting: well sorted

Mineral components: white specks

Rock Classification: limestone

Sauget Area 1

Rock Classification worksheet

Litt I, 116-118, 10 paces

Color:

light gray

Rock Quality:

poor

Porosity:

none

Beds:

planes, very thin to medium

Thickness:

0.125 inches to 4 inches

Contact:

distinct

Foliation:

plane

Joints:

horizontal

Weathering:

none observable

Surface:

etch

Hardness:

moderate to hard

Texture:

2

Grain Shape:

very fine to micro granular

Sorting:

well sorted

Mineral components:

white specks throughout

Rock Classification:

Sauget Area 1	
Rock Classification worksheet <i>Sity I</i>	
<i>118-1265' Sand to 120.5; unknown rock type 120.5-126.5</i>	
Color:	<i>no core sample 120.5 to 126, had to stop drilling to reset 4 inch casing</i>
Rock Quality:	
Porosity:	
Beds:	
Thickness:	
Contact:	
Foliation:	
Joints:	
Weathering:	
Surface:	
Hardness:	
Texture:	
Grain Shape:	
Sorting:	
Mineral components:	
Rock Classification:	

Sauget Area 1

Rock Classification worksheet

Site I, piece 12-1 through 12-5 126.5-127.02

Color: light olive gray

Rock Quality: excellent, massive

Porosity: none

Beds: planes, very thin to thin

Thickness: 0.25 to 2 inches

Contact: distinct

Foliation: planes

Joints: wavy, wavy, horizontal

Weathering: slight at top and bottom of piece
bottom of piece 4+5 dark gray & pitted

Surface: solid

Hardness: mod to hard

Texture: very fine to micro granular

Grain Shape: rounded to subangular

Sorting: well sorted

Mineral components: some white specks and nodules

Rock Classification: limestone

Sauget Area 1

Rock Classification worksheet

Sub I, piece 12-6 127.02 - 127.54

Color: light gray

Rock Quality: excellent

Porosity: none

Beds: planar, medium

Thickness: 6-25 cm, medium

Contact: distinct

Foliation: planar

Joints: wavy, horizontal, clay filled

Weathering: slight, pitted surface at top and bottom

Surface: solid

Hardness: moderate to hard

Texture: very fine to micro granular, flaky breakage

Grain Shape: ~~non~~ subrounded to subangular

Sorting: well sorted

Mineral components: disseminated white specks, calcite

Rock Classification: limestone

Sauget Area 1

Rock Classification worksheet

127.54-127.92 proximity

Site I, piece 12-7

127.501-128.54

Color:

light gray

Rock Quality:

2x collect

Porosity:

none

Beds:

planar, thick

Thickness:

12 inches

Contact:

disconformity

Foliation:

planar

Joints:

Horizontal, wavy fine lines + contact
lines 2 inches from bottom

Weathering:

slightly pitted surfaces at top & bottom of
piece

Surface:

solid

Hardness:

hard

Texture:

very fine to microgranular

Grain Shape:

subrounded to angular

Sorting:

well sorted

Mineral components:

calcite, a few white specks

Rock Classification:

limestone

Sauget Area 1

Rock Classification worksheet

Site I, piece 12-8 128.54 - 129.35

Color: light gray

Rock Quality: excellent

Porosity: none

Beds: planes medium

Thickness: 9.75 inches

Contact: distinct

Foliation: planar

Joints: very fine lines, horizontal to sub-horizontal

Weathering: pitted surface at top, dull clayey at bottom

Surface: solid

Hardness: moderate to hard

Texture: very fine to microgranular

Grain Shape: subrounded to subangular

Sorting: well sorted

Mineral components: feldspar, white specks

Rock Classification: limestone

Sauget Area 1

Rock Classification worksheet

Site I, 12-9; 129.35-132.04

Color: light gray

Rock Quality: excellent

Porosity: none

Beds: planar, very thick

Thickness: 32.25 inches

Contact: disconformity

Foliation: planar

Joints: planar, subvertical, horizontal, three

Weathering: slight at top & bottom

Surface: smooth

Hardness: moderate to hard

Texture: very fine to microgranular

Grain Shape: subrounded to subangular

Sorting: well sorted

Mineral components: disseminated white specks

Rock Classification: limestone

Sauget Area 1

Rock Classification worksheet

Set I, 12, piece 10411, 132.04 - 132.35

Color: light gray

Rock Quality: excellent

Porosity: none

Beds: planes very thin to thin

Thickness: 0.75 to 3 inches

Contact: distinct

Foliation: plane

Joints: one in center of piece 11, very filled

Weathering: pitted surface on bottom of piece 11

Surface: solid

Hardness: moderate to hard

Texture: very fine to medium

Grain Shape: subangular to angular

Sorting: well sorted

Mineral components: clay, calcite

Rock Classification: limestone

Sauget Area 1
Rock Classification worksheet

Set I, piece 12, 132.35 - 132.77

Color: light gray

Rock Quality: excellent

Porosity: none

Beds: planar, medium

Thickness: 5 inches medium

Contact: distinct

Foliation: planar

Joints: wavy fine lines, med gray, N5, bands and top of bottom

Weathering: mod ~~inter~~ gray - N5, fine pit in bottom of piece

Surface: solid

Hardness: mod to hard, dark gray bands slightly more soft than middle

Texture: very fine to med granular

Grain Shape: sub rounded (dark bands), sub rounded to sub angular

Sorting: well sorted

Mineral components: Calc

Rock Classification: limestone

Sauget Area 1

Rock Classification worksheet

Set I piece 12-13, 132.77-133.87

Color:

light gray

Rock Quality:

excellent

Porosity:

none

Beds:

planar, thick

Thickness:

13 inches, thick

Contact:

distinct

Foliation:

planar

Joints:

some wavy fines filled lines

Weathering:

slight at top & bottom

Surface:

solid

Hardness:

moderate to hard

Texture:

very fine to micro granular

Grain Shape:

subrounded to subangular

Sorting:

well sorted

Mineral components:

white speckles

Rock Classification:

limestone

Sauget Area 1
Rock Classification worksheet

Sill I, piece 12-14 132.87-132.97

Color: light gray

Rock Quality: excellent

Porosity: none

Beds: planar, thin

Thickness: 1.25,

Contact: distinct

Foliation: planar

Joints: wavy, filled fine horizontal lines

Weathering: slight at top + bottom ends

Surface: solid

Hardness: mod. to hard

Texture: mass

Grain Shape: —

Sorting: —

Mineral components: —

Rock Classification: limestone

Sauget Area 1
Rock Classification worksheet

Site: I, 12-15, 13.2.97 - 13.3.99

Color: light gray

Rock Quality: excellent

Porosity: none

Beds: planar - thick

Thickness: 12-25 inches

Contact: distinct

Foliation: planar

Joints: ~~planar~~ a few, horizontal wavy fine lenses

Weathering: slight at top and bottom, pitted surfaces

Surface: solid, some darker gray, scarpers possibly fossils

Hardness: mod to hard

Texture: medium granular

Grain Shape: rounded

Sorting: well sorted

Mineral components: —

Rock Classification: limestone

Sauget Area 1

Rock Classification worksheet

Silt. T. 12-16, 133.99 - 134.59

Color:

light gray

Rock Quality:

excellent

Porosity:

silt

Beds:

planar, medium

Thickness:

7.25, medium

Contact:

distinct

Foliation:

planar

Joints:

a few wavy, filled horizontal lines

Weathering:

slight as pitted surface on top & bottom

Surface:

solid

Hardness:

moderate to hard

Texture:

micro granular

Grain Shape:

rounded

Sorting:

well sorted

Mineral components:

Rock Classification:

limestone

Sauget Area 1	134.59-135.01 porosity
Rock Classification worksheet	
Site I, 6.2-17 & 18	134.59-135.42
Color:	light gray
Rock Quality:	excellent
Porosity:	none
Beds:	planar, medium
Thickness:	10.0
Contact:	distinct
Foliation:	planar
Joints:	none observed
Weathering:	slight pitted top surface
Surface:	smooth
Hardness:	mod to hard
Texture:	microgranular
Grain Shape:	rounded
Sorting:	well sorted
Mineral components:	CaCO ₃
Rock Classification:	Limestone

Sauget Area 1

Rock Classification worksheet

Silt I, 12-19 136.5-137.04

Color: light gray

Rock Quality: excellent

Porosity: none

Beds: planar, medium

Thickness: 11.25

Contact: distinct

Foliation: planar

Joints: few none

Weathering: slight top & bottom

Surface: smooth

Hardness: mod to hard

Texture: fine to medium granular

Grain Shape: subrounded to subangular

Sorting: well sorted

Mineral components: clay

Rock Classification: silty clay

Sauget Area 1

Rock Classification worksheet

SUIT 12-30

137.44 - 137.61

Color:

light gray

Rock Quality:

excellent

Porosity:

non

Beds:

planar

Thickness:

2.125

Contact:

distinct

Foliation:

planar

Joints:

fine wavy, horizontal, filled, trace

Weathering:

pit at surface, at top, smooth, slightly (shale?)
Vegetation at bottom

Surface:

solid

Hardness:

mod to hard

Texture:

micro granular

Grain Shape:

subangular to sub-angular

Sorting:

fine

Mineral components:

CaCO₃

Rock Classification:

limestone

Sauget Area 1

Rock Classification worksheet

137.61 - 137.84 (percent)

Lib 5 12-21

137.61 - 138.05

Color:

light gray

Rock Quality:

excellent

Porosity:

low

Beds:

planar

Thickness:

5.25

Contact:

distinct

Foliation:

planar

Joints:

~~jointed~~

Weathering:

slight at top & bottom

Surface:

solid

Hardness:

mod to hard

Texture:

microgranular

Grain Shape:

subrounded to subangular

Sorting:

med

Mineral components:

calc

Rock Classification:

limestone

Sauget Area 1

Rock Classification worksheet

Site I, 12-22

138.05 - 139.47

Color:

light gray

Rock Quality:

excellent

Porosity:

none

Beds:

planar, best

Thickness:

17.0, thick

Contact:

contacted

Foliation:

planar; white, irregular shaped in bottom 7.5 inches

Joints:

horizontal to subhorizontal fine, some filled with

Weathering:

dark blue surface on top and bottom surface

Surface:

solid top 9.5 inches, small pits scattered in bottom 7.5 inches

Hardness:

moderate to hard

Texture:

medium grained

Grain Shape:

cr

Sorting:

well sorted

Mineral components:

white crystals in bottom 7.5 inches; do not effervesce in HCL

Rock Classification:

limestone

Sauget Area 1
Rock Classification worksheet

SuT, p. 12-23 10739.47-141.72

Color: light gray

Rock Quality: excellent

Porosity: none

Beds: planar, thick

Thickness: 27 inches

Contact: distinct

Foliation: planar

Joints: no jointing except at bottom

Weathering: black pitted surface at bottom

Surface: somewhat pitted in top 3.5 inches

Hardness: moderate to hard

Texture: coarse grained

Grain Shape:

Sorting:

Mineral components: a bean-bop shape in top 5 inches had apparent
minerals in it

Rock Classification: limestone

Sauget Area 1

Rock Classification worksheet

Set I 12-24-26 141.72-142.03

Color: light gray

Rock Quality: excellent

Porosity: none

Beds: planar

Thickness: 3.75 inches total, each \approx 1.25 inches

Contact: distinct

Foliation: planar

Joints: multitude of fine, wavy, subhorizontal, low
slight, blocky fractures separating pieces

Weathering: along fracture lines separating pieces

Surface: smooth

Hardness: 12.7 to 13.0

Texture: mass

Grain Shape: —

Sorting: —

Mineral components: —

Rock Classification: limestone

Sauget Area 1

Rock Classification worksheet

142.03 - 144.21

Section 10-27

141.72 - 143.90

Color:

light gray

Rock Quality:

excellent

Porosity:

none

Beds:

planar thick - thin irregular shaped blocks
in top 2/3, with blocky bottom 1/3

Thickness:

26.125 in.

Contact:

clear

Foliation:

planar

Joints:

2 or more, fine but horizontal fine lines

Weathering:

slight at top & bottom ends

Surface:

smooth

Hardness:

mod to hard

Texture:

non-crystalline

Grain Shape:

angular

Sorting:

well

Mineral components:

calc

Rock Classification:

limestone

Sauget Area 1

Rock Classification worksheet

Set I 12-28 144.21 - 144.56
~~143.90 - 144.25~~

Color: light gray

Rock Quality: excellent

Porosity: none

Beds: planar, medium

Thickness: 4-5 inches

Contact: distinct

Foliation: planar

Joints: a few are y lines at top

Weathering: a pitted surface on top & bottom

Surface: solid

Hardness: mod-hard

Texture: medium

Grain Shape: rounded

Sorting: well sorted

Mineral components: —

Rock Classification: limestone

Sauget Area 1

Rock Classification worksheet

144.56 - 145.27

Set I, 12-29, 144.25 - 144.96

Color:

light gray

Rock Quality:

excellent

Porosity:

none

Beds:

planar, medium

Thickness:

8.5

Contact:

distinct

Foliation:

planar

Joints:

as fine horizontal to subhorizontal lines

Weathering:

slight as pitted clay surfaces at top and bottom

Surface:

solid

Hardness:

mod to hard

Texture:

microgranular

Grain Shape:

—

Sorting:

—

Mineral components:

—

Rock Classification:

limestone

Sauget Area 1

Rock Classification worksheet

Site I, 12-30 145.27-145.70
144.96-145.39

Color: light gray

Rock Quality: excellent

Porosity: none

Beds: planar, medium

Thickness: 5.125

Contact: distinct

Foliation: planar

Joints: clay filled at top black stained + pitted on bottom

Weathering: pitted black bottom

Surface: solid; pitted filled fracture in middle

Hardness: moderate to hard

Texture: micro granular

Grain Shape: rounded

Sorting: well

Mineral components: pyrite traces pyrite

Rock Classification: limestone

Sauget Area 1

Rock Classification worksheet

Sile I, 12-31, 145.70 - 146.91
~~145.39 - 146.6~~

Color:

light gray

Rock Quality:

excellent

Porosity:

none

Beds:

planar, thick

Thickness:

14.50

Contact:

distinct

Foliation:

planar

Joints:

one subhorizontal, stylolite in middle

Weathering:

pitted surface on top of core

Surface:

solid

Hardness:

moderate to hard

Texture:

very fine to microcrystalline

Grain Shape:

rounded

Sorting:

well

Mineral components:

some faint white blotches

Rock Classification:

limestone

GSI Job No. G-2876
Issued: August 28, 2006



BEDROCK TRANSPORT EVALUATION

Sauget Area 1, Sauget and Cahokia, Illinois

ATTACHMENT J-3 – THIN SECTION ANALYSIS REPORTS

Reports of Thin Section Analysis from American Petrographic Services, Inc.
(Source: *pages 147A-1 to 147A-21 from Volume 2 of Field Sampling Report, O'Brien & Gere, September 2000*)



AMERICAN
PETROGRAPHIC
SERVICES, INC.

July 13, 2000

O'Brien & Gere Engineers, Inc.
12250 Weber Hill Road
St. Louis, MO 63127

Attn: William Wright

Subj.: Solutia, Inc.
Sauget Area 1
APS Job No. 10-01078

Dear Mr. Wright:

This letter presents the results of our observations made on 29 rock core samples. The scope of our work was limited to visually documenting the relative porosity of the rock samples or selected areas within the rock samples by thin section analysis. The samples were submitted by Mr. William Wright of O'Brien & Gere, Inc. on June 5, 2000. Our work was authorized at that time.

Observations

Sample	Lithology	Porosity	Comments
G, 112.2 -112.46	dolomitic limestone, biosparite	moderate	dolomitized throughout
G, 114.74-115.07	limestone, pel-biosparite	low	well cemented
G, 116.11-116.53	limestone, oo-pel-biosparite	low	well cemented
G, 118.36-118.51	limestone, oo-pel-biosparite	high	many stylolites
G, 120.56-120.89	limestone, pel-biosparite	low	few scattered interfragment pores
G, 122.41-122.71	limestone, biomicrite	med-low	dense, 2 thin stylolites
G, 124.17-124.46	limestone, oo-pel-biosparite	low	dense
G, 126.79-127.13	limestone, oo-pel-biosparite	low	dense
G, 128.42-128.73	limestone, oo-pel-biosparite	high	concentrations of subparallel stylolites
G, 130.80-131.10	dolomitic limestone, biosparite	moderate	dolomitized zones throughout

Sample	Lithology	Porosity	Comments
H, 111.83-112.19	limestone, biosparite	moderate	some sutured stylolites
H, 113.46-113.81	limestone, biosparite	moderate	some crude stylolites
H, 115.76-116.03	dolomitic limestone,	high	dolomitized throughout
H, 118.04-118.46	calcitic dolostone, biosparite	high	dolomitized throughout
H, 119.87-120.29	limestone, oo-pel-biosparite	low	dense sparite cement
H, 121.43-121.63	limestone, biosparite	moderate	some stylolite swarms
H, 122.5- 122.79	limestone, biosparite	mod-low	one stylolite swarm
H, 125.30-125.59	limestone, oo-pel-biosparite	mod-low	a few pores in drusy sparry cavities
H, 128.99-129.39	limestone, pel-biosparite	moderate	some crude stylolites
H, 131.04-131.43	limestone, biomicrite	low	dense micrite matrix
I, 127.54-127.92	limestone, pel-biosparite	low	dense sparite cement
I, 129.85-130.27	not received		
I, 131.27-131.55	limestone, pel-biosparite	low	dense sparite cement
I, 133.08-133.41	limestone, pel- biomicrite	low	dense micrite matrix
I, 134.59-135.01	limestone, oo-pel-biosparite	low	dense sparite cement
I, 137.61-137.84	limestone, pel-biosparite	low	very dense and fine sparite cement
I, 138.93-139.31	dolostone, micro sparite	high	large cavities throughout
I, 142.57-142.87	dolomitic limestone, biomicrite	high	many lg. pores in dolomitized areas
I, 145.27-145.46	limestone, pelmicrite	low	no visible porosity
I, 146.63-146.88	limestone, biomicrite	low	dense micrite matrix

Mr. William Wright
July 13, 2000
Page 3

Procedures

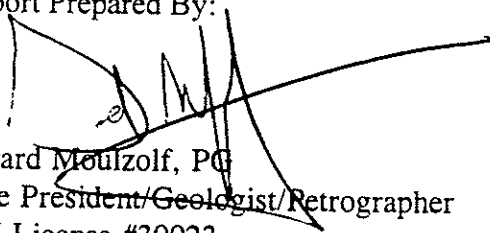
Thin section analysis was performed in accordance with APS Standard Operating Procedure 00 LAB 016, "Preparation of Thin Sections for Petrographic Analysis, APS Method". The selected sections of the core samples are first highly polished, then epoxied to a glass slide. The excess sample is cut from the glass and the slide is polished until the material reaches 25 microns or less in thickness. The resulting samples were reviewed under a petrographic microscope at magnifications up to 1000x. Our conclusions are based on the work performed, our observations, and experience. Laboratory testing was performed on June 13, 2000 and subsequent dates. Photos are included to illustrate our conclusions and observations.

Remarks

The core samples will be retained for a period of at least thirty days from the date of this report. Unless further instructions are received by that time, the sample may be discarded. The geologic services for this project have been conducted in a manner consistent with that level of care and skill exercised by members of the profession currently practicing in this area under similar budget and time constraints. No warranty, express or implied, is made.

If I can be of further assistance to you, please contact me at (651) 659-1346.

Report Prepared By:

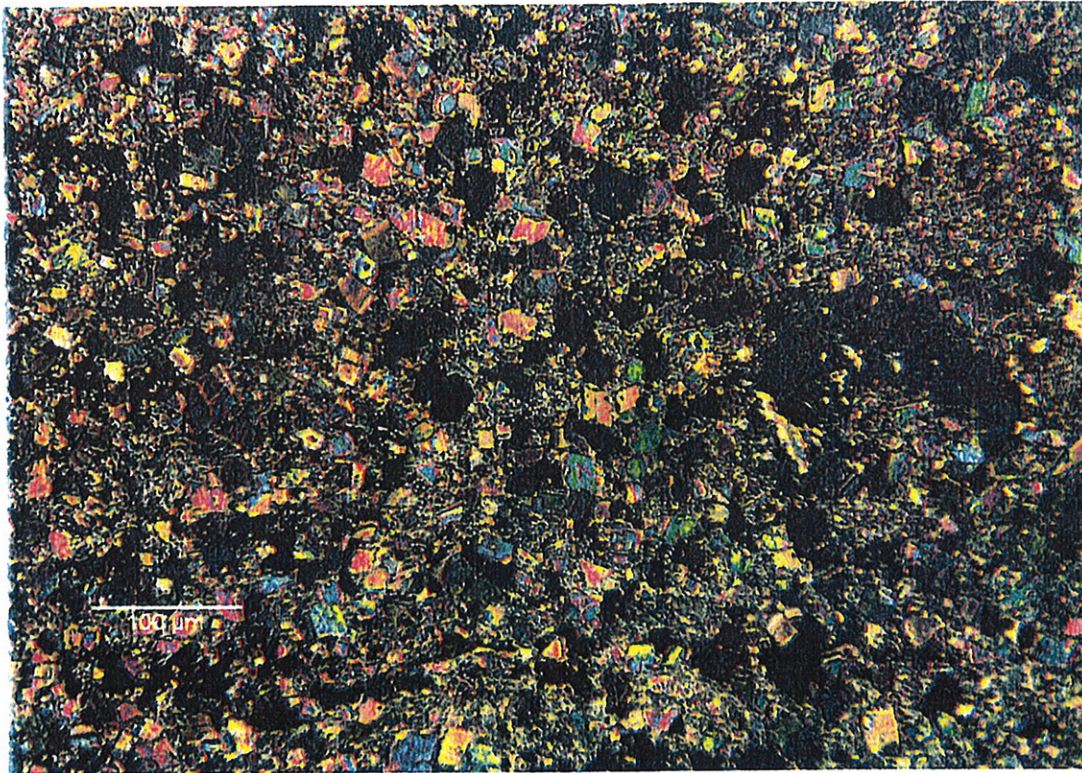


Gerard Moulzolf, PG
Vice President/Geologist/Petrographer
MN License #30023

APS#
PROJECT:

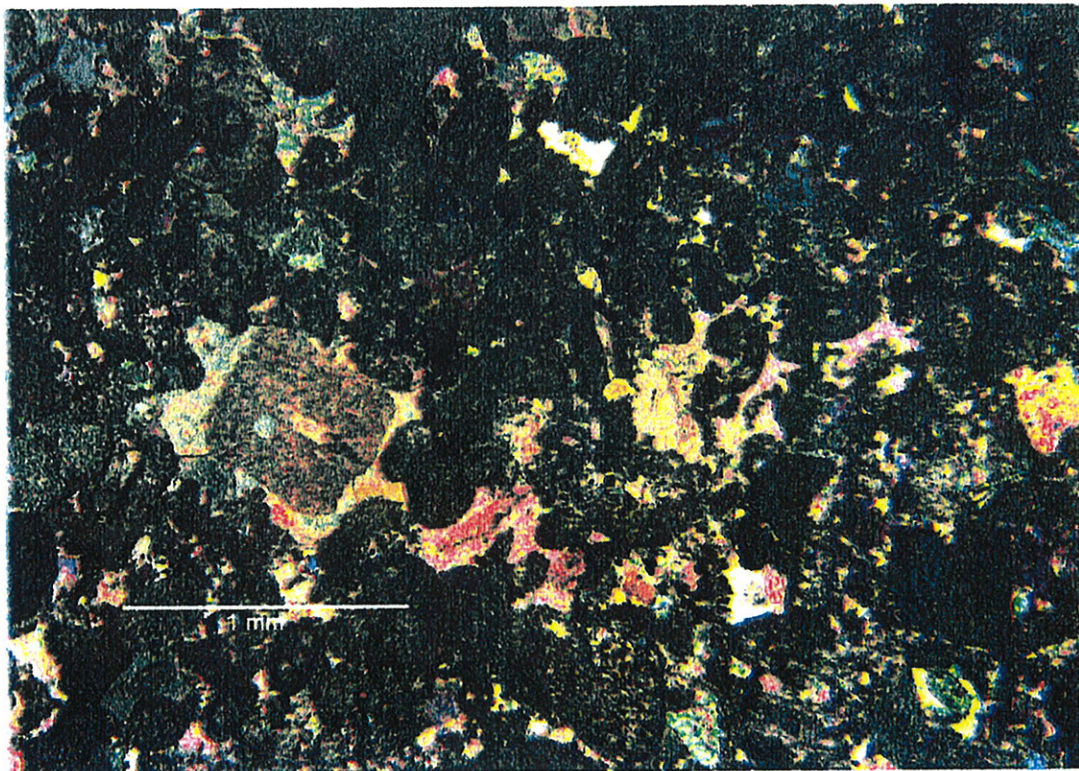
10-01078
Solutia, Inc.
Sauget Area 1

DATE: JULY 12, 2000



SAMPLE IDENTIFICATION: G112.2 -112.46 SAMPLE DESCRIPTION: Dolomitic limestone. Euhedral dolomite rhombs in finer calcite matrix. Some of the black (extinct) areas are voidspace; under cross polarized light.

MAGNIFICATION: 200x

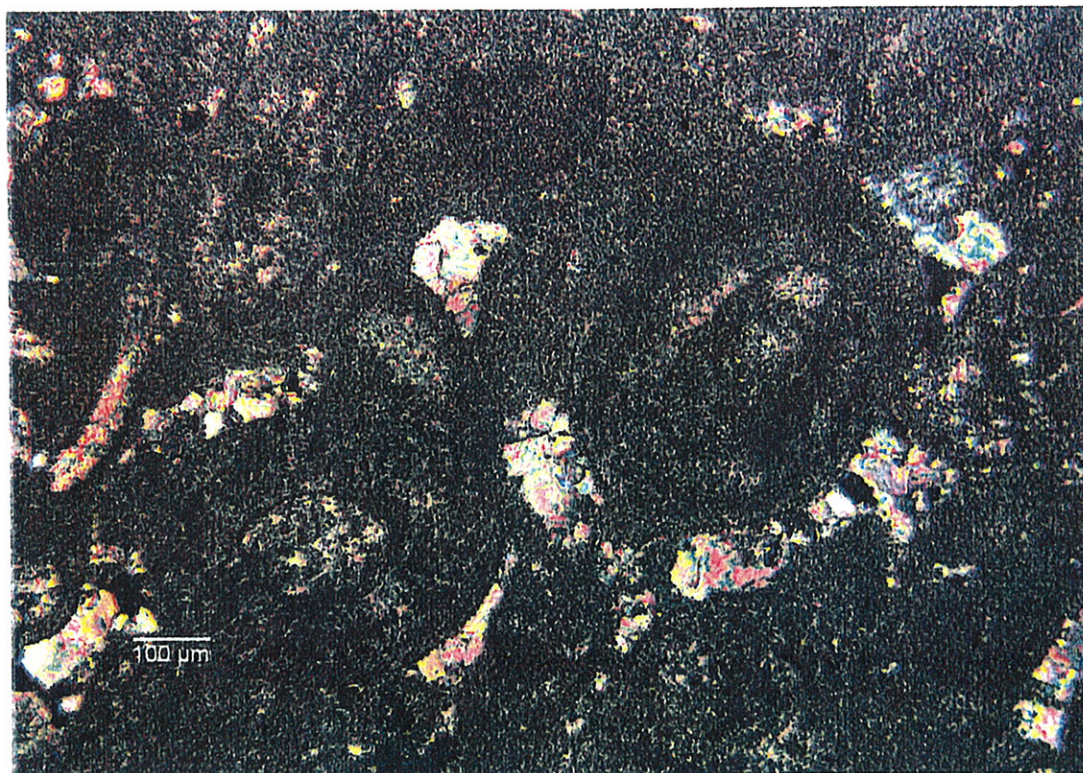


SAMPLE IDENTIFICATION: G114.74-115.07 SAMPLE DESCRIPTION: Relatively dense pel-biosparite. Drusy sparite cement and syntaxial calcite growth around echinoderm fragments fill intergranular space cross polarized light

MAGNIFICATION: 40x

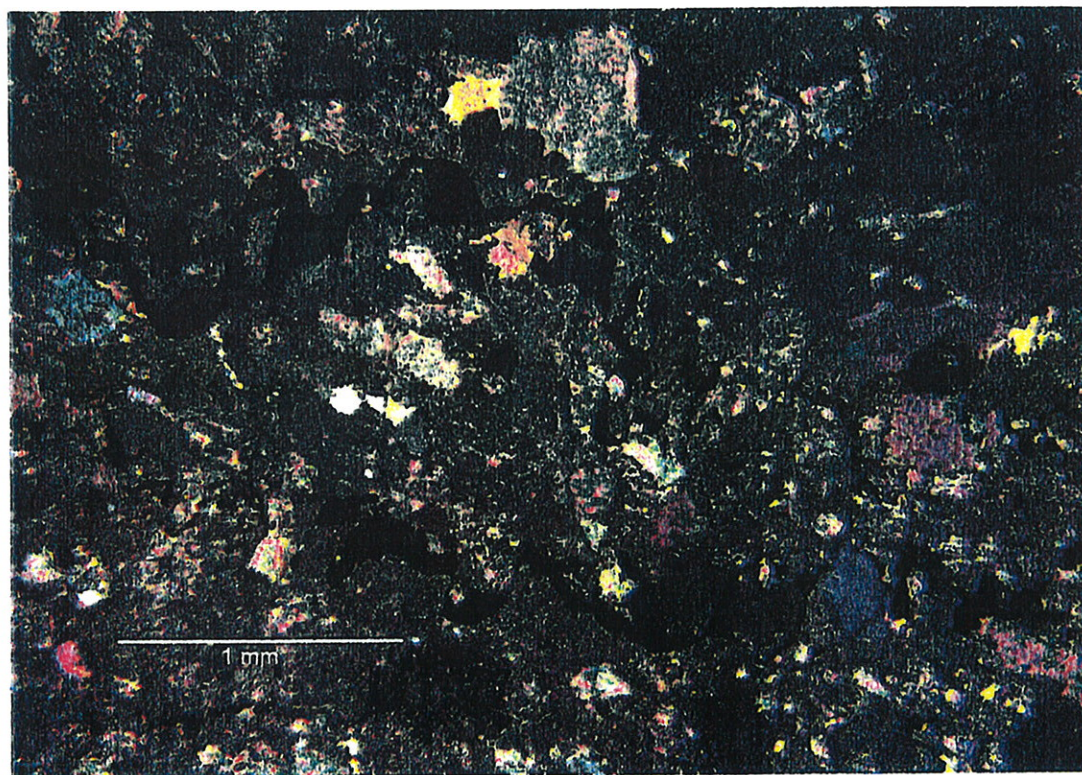
APS# 10-01078
PROJECT: Solutia, Inc.
Sauget Area 1

DATE: JULY 12, 2000



SAMPLE IDENTIFICATION: G,116.11 -116.53 SAMPLE DESCRIPTION: Oo-pel-biosparite. Drusy sparite cement fills intergranular spaces. cross polarized light.

MAGNIFICATION: 100x

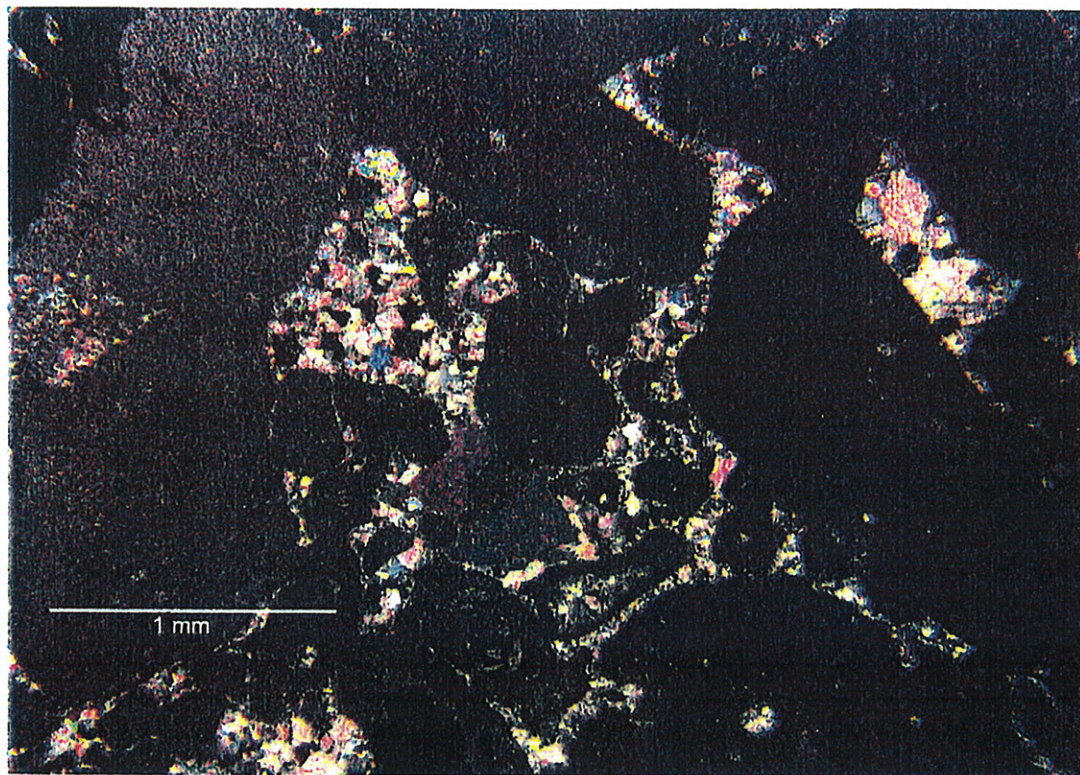


SAMPLE IDENTIFICATION: G,118.36-118.51 SAMPLE DESCRIPTION: Stylolites; appearing as black sutured voidspaces in the oo-pel-biosparite. cross polarized light

MAGNIFICATION: 40x

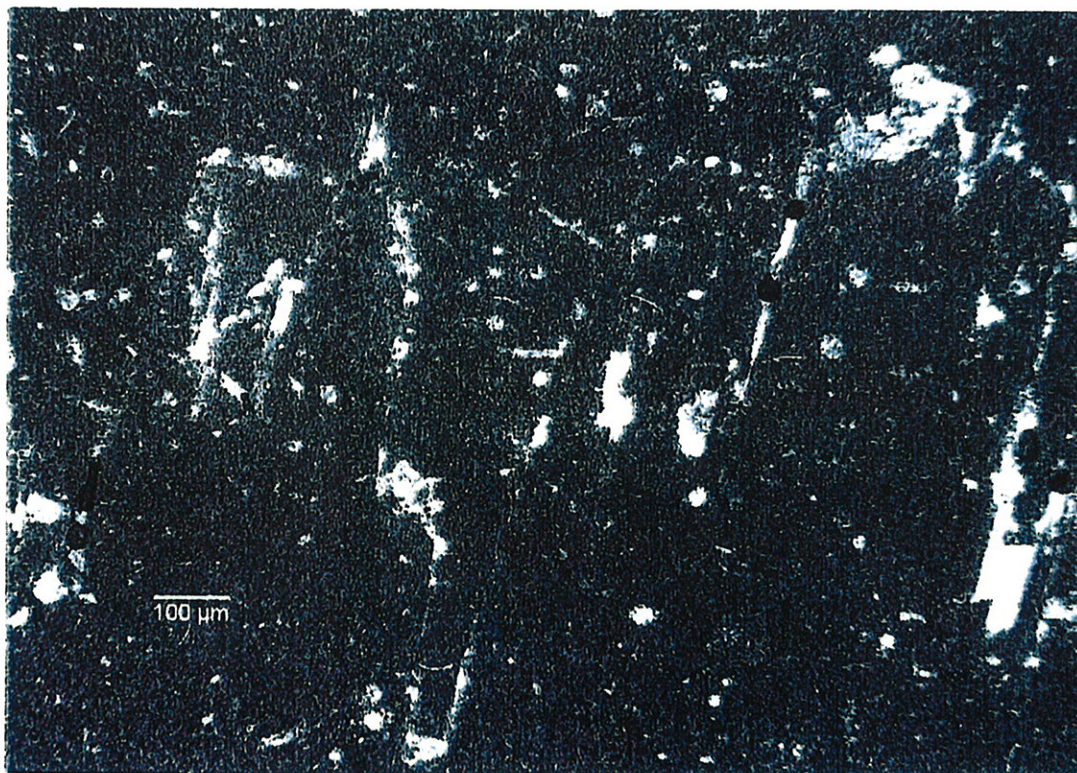
APS# 10-01078
PROJECT: Solutia, Inc.
Sauget Area 1

DATE: JULY 12, 2000



SAMPLE IDENTIFICATION: G,120.56 -120.89 SAMPLE DESCRIPTION: Pel-biosparite. Drusy sparite cement fills intergranular spaces. cross polarized light.

MAGNIFICATION: 40x



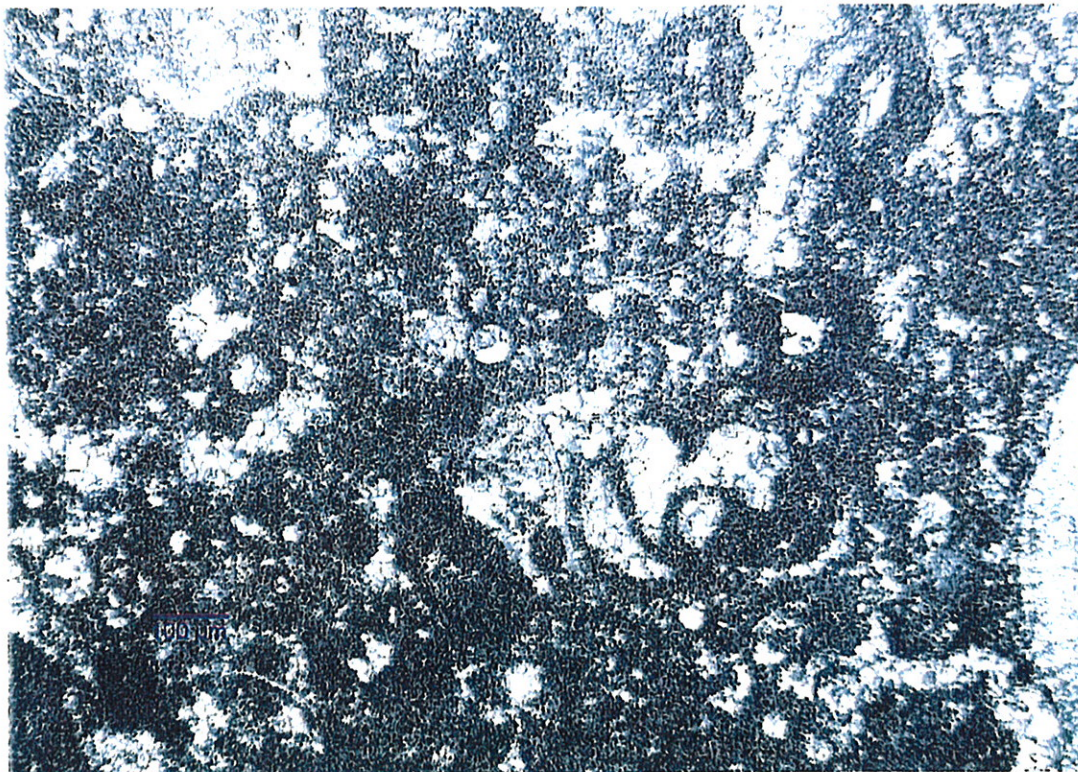
SAMPLE IDENTIFICATION: G,122.41-122.71 SAMPLE DESCRIPTION: Stylolite, sutured white voidspaces in the fine micrite matrix. plane polarized light

MAGNIFICATION: 100x

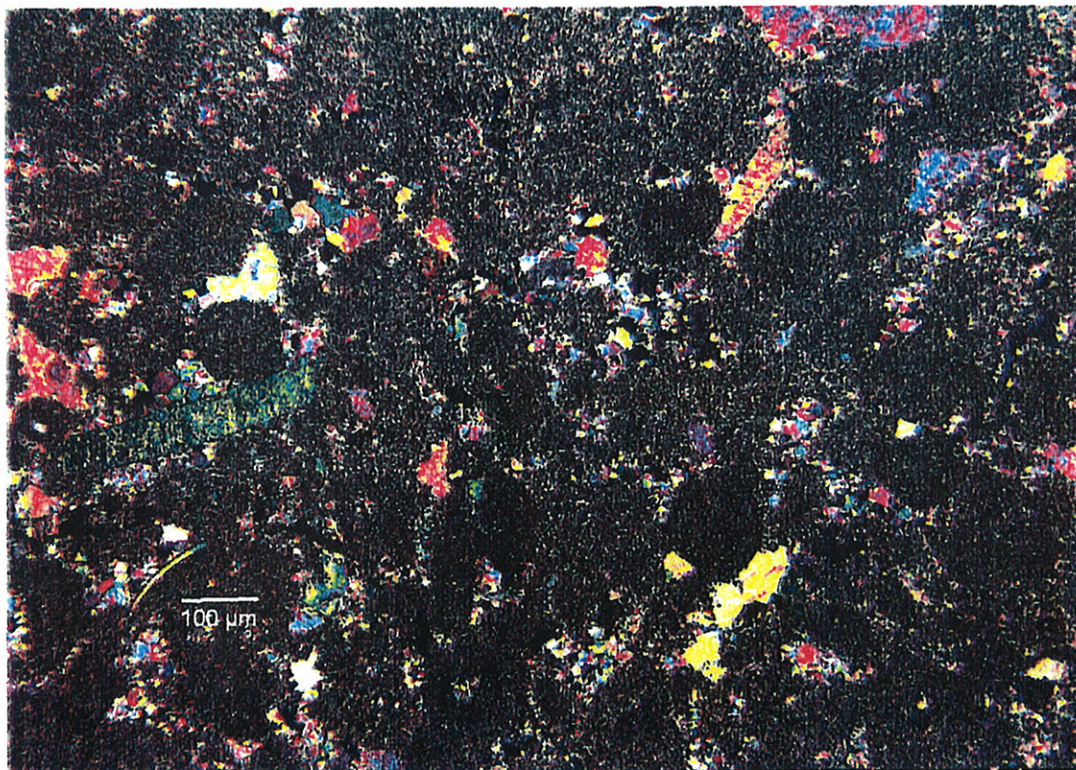
APS#
PROJECT:

10-01078
Solutia, Inc.
Sauget Area 1

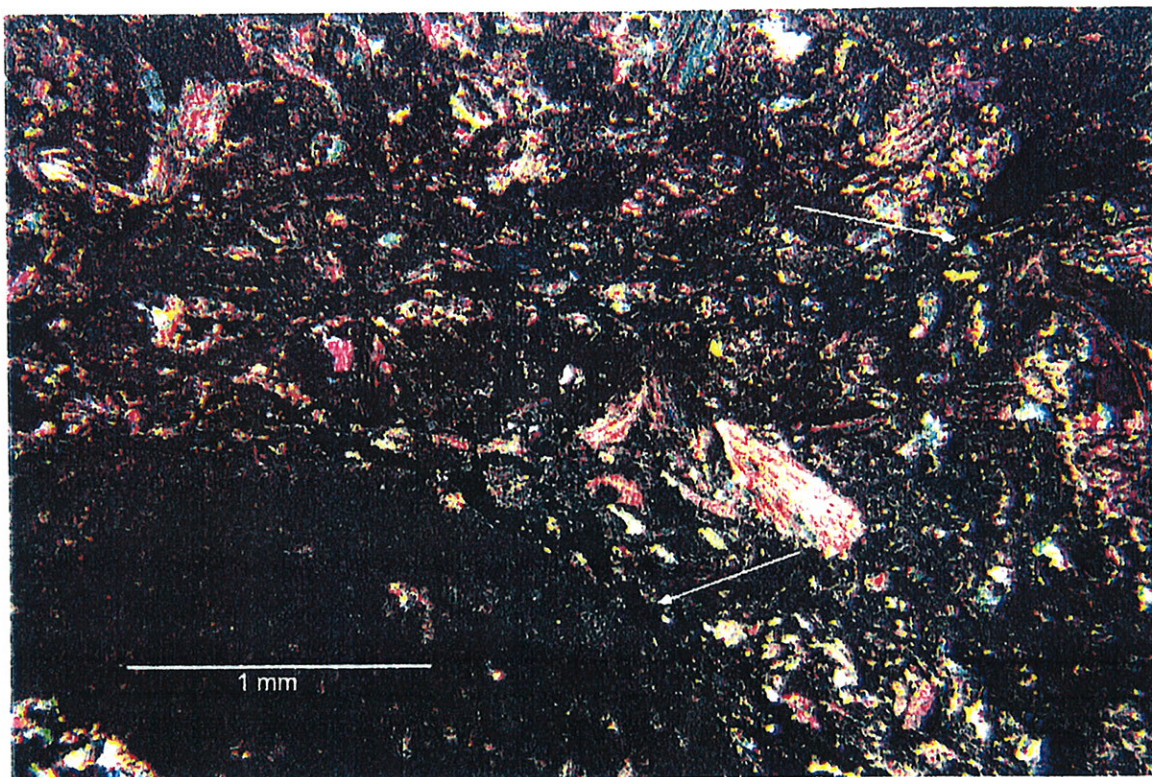
DATE: JULY 12, 2000



SAMPLE IDENTIFICATION: G,124.17 -124.46 SAMPLE DESCRIPTION: Oo-pel-biosparite. Drusy sparite cement fills intergranular spaces. plane polarized light.
MAGNIFICATION: 100x

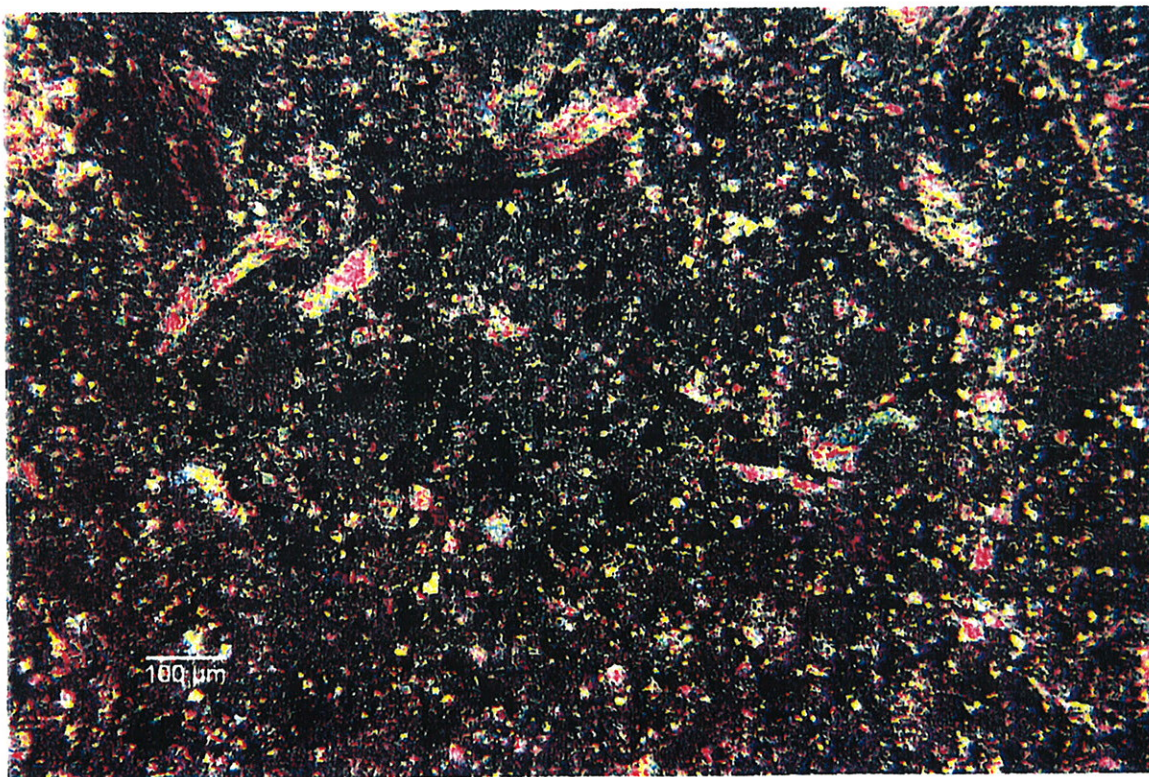


SAMPLE IDENTIFICATION: G,126.79-127.13 SAMPLE DESCRIPTION: Oo-pel-biosparite. Drusy sparite cement fills intergranular spaces. cross polarized light.
MAGNIFICATION: 100x



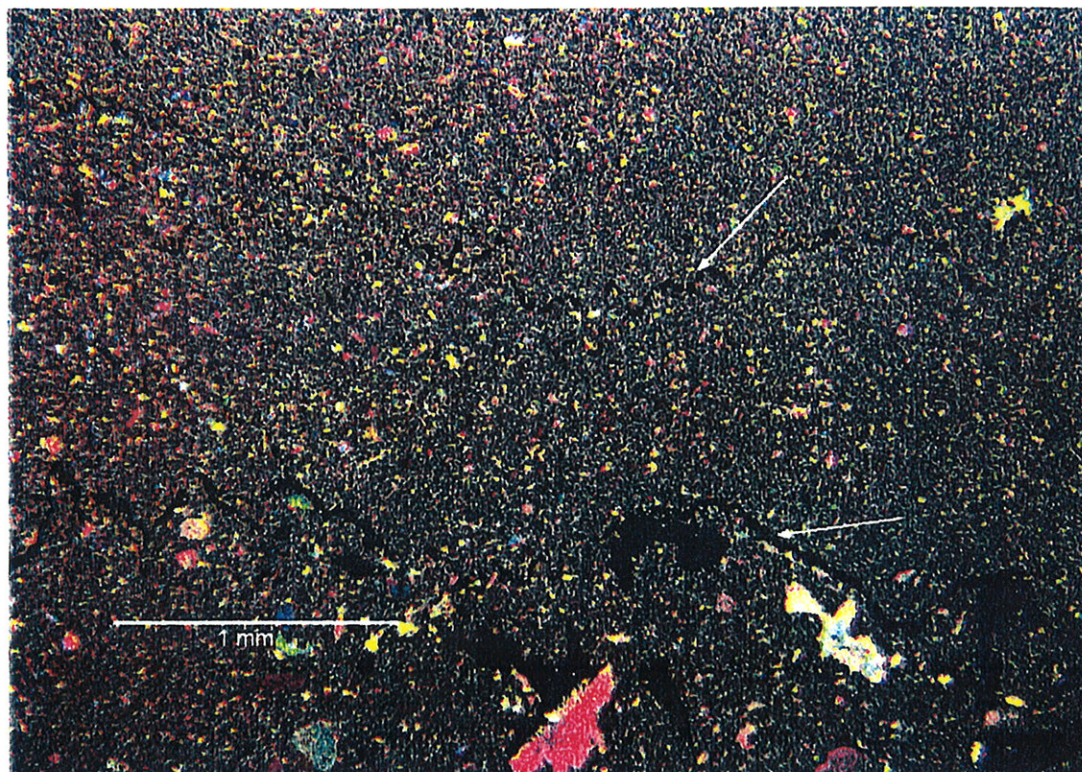
SAMPLE IDENTIFICATION: G_{128.42-128.73} SAMPLE DESCRIPTION: Oo-pel-biosparite. Concentrations of crude stylolite voidspace. cross polarized light.

MAGNIFICATION: 40x



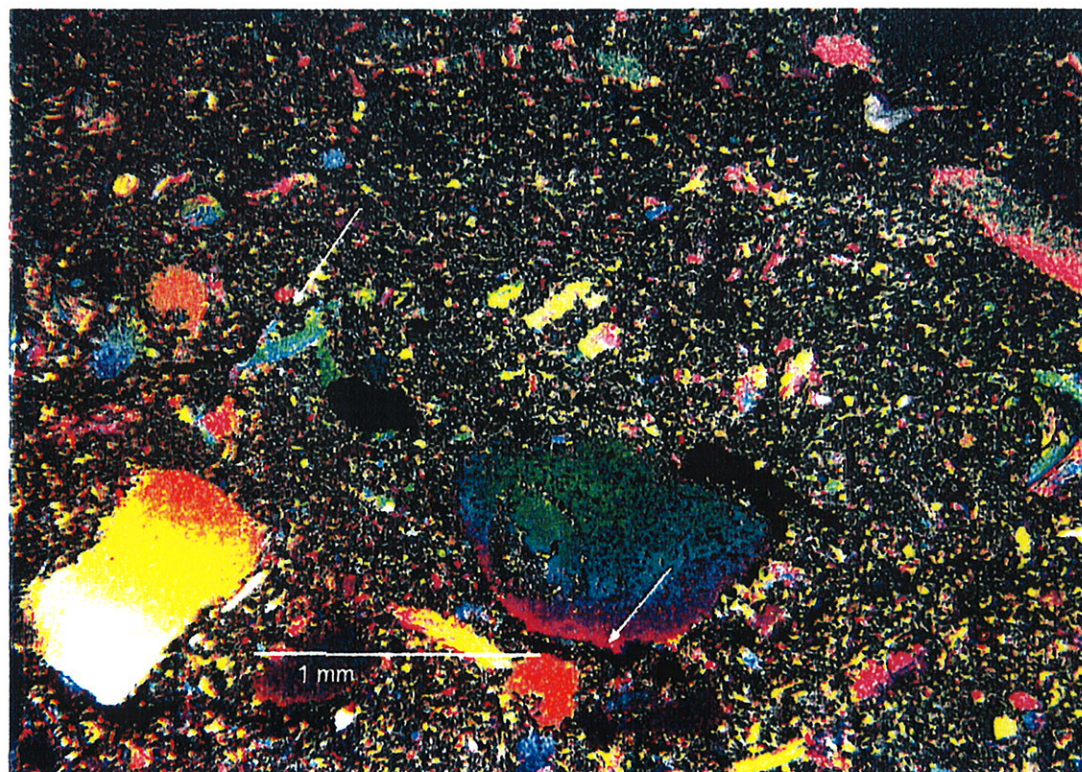
SAMPLE IDENTIFICATION: G_{130.80-131.10} SAMPLE DESCRIPTION: Dolomitic limestone. Fine, euhedral dolomite rhombs occur throughout. Moderate porosity. cross polarized light.

MAGNIFICATION: 100x



SAMPLE IDENTIFICATION: H,111.83-112.19 SAMPLE DESCRIPTION: Biosparite. Sutured stylolite voidspace in black under cross polarized light.

MAGNIFICATION: 40x



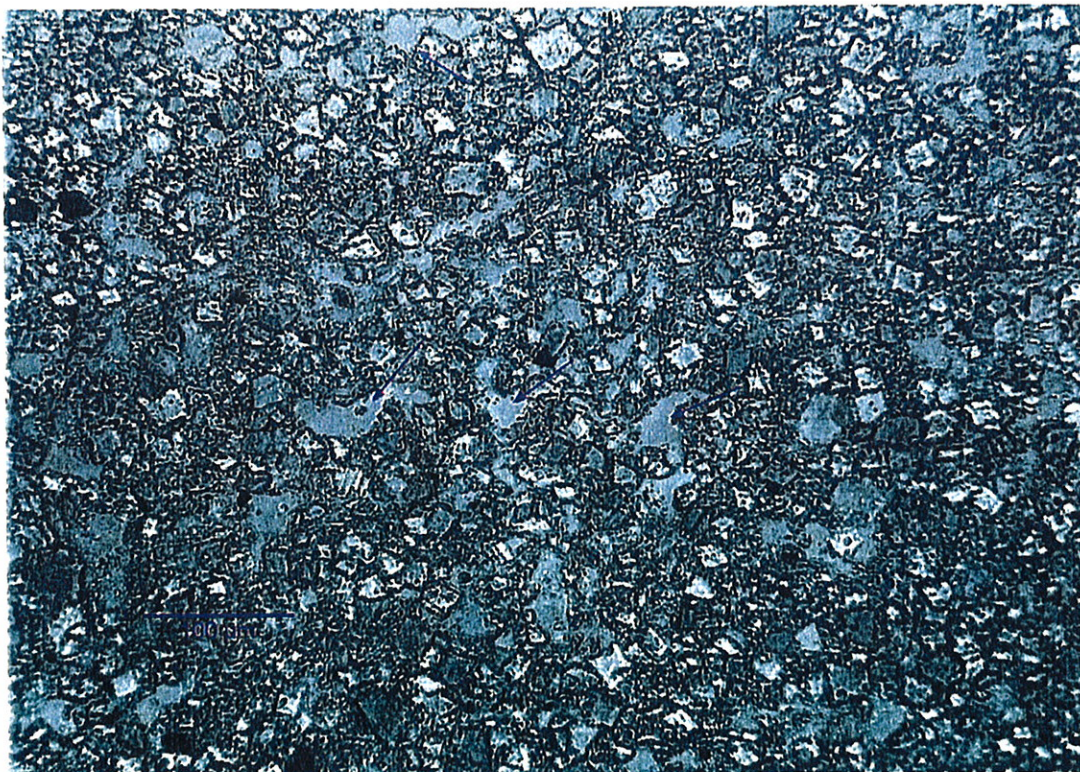
SAMPLE IDENTIFICATION: H,113.46-113.81 SAMPLE DESCRIPTION: Biosparite. Crude stylolite voidspace in black under cross polarized light.

MAGNIFICATION: 40x

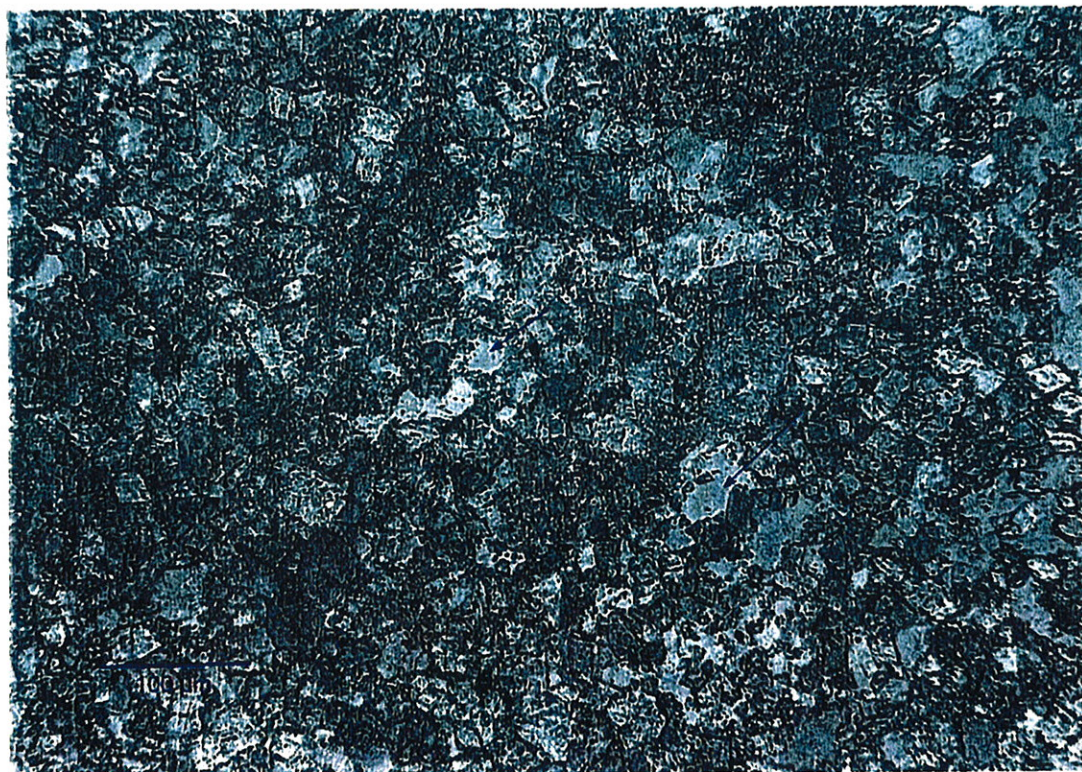
APS#
PROJECT:

10-01078
Solutia, Inc.
Sauget Area 1

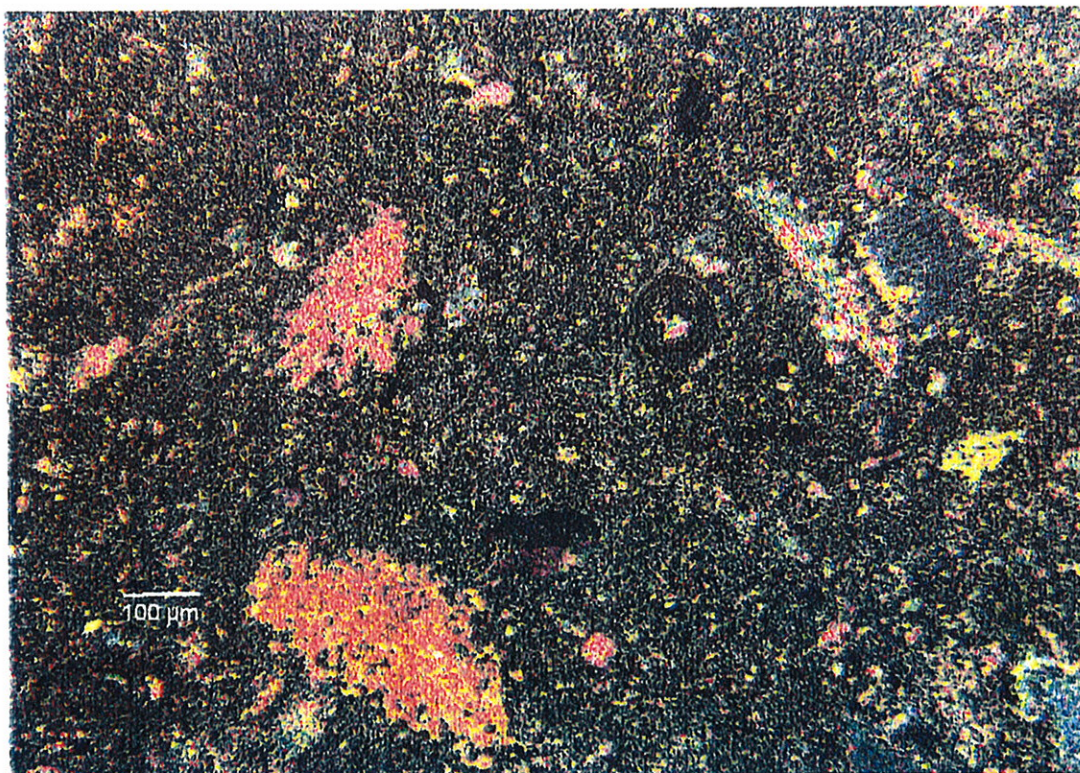
DATE: JULY 12, 2000



SAMPLE IDENTIFICATION: H,115.76-116.03 SAMPLE DESCRIPTION: Dolomitic limestone. Porespaces noted by blue arrows. Dolomite appears as euhedral rhombs. plane polarized light.
MAGNIFICATION: 200x

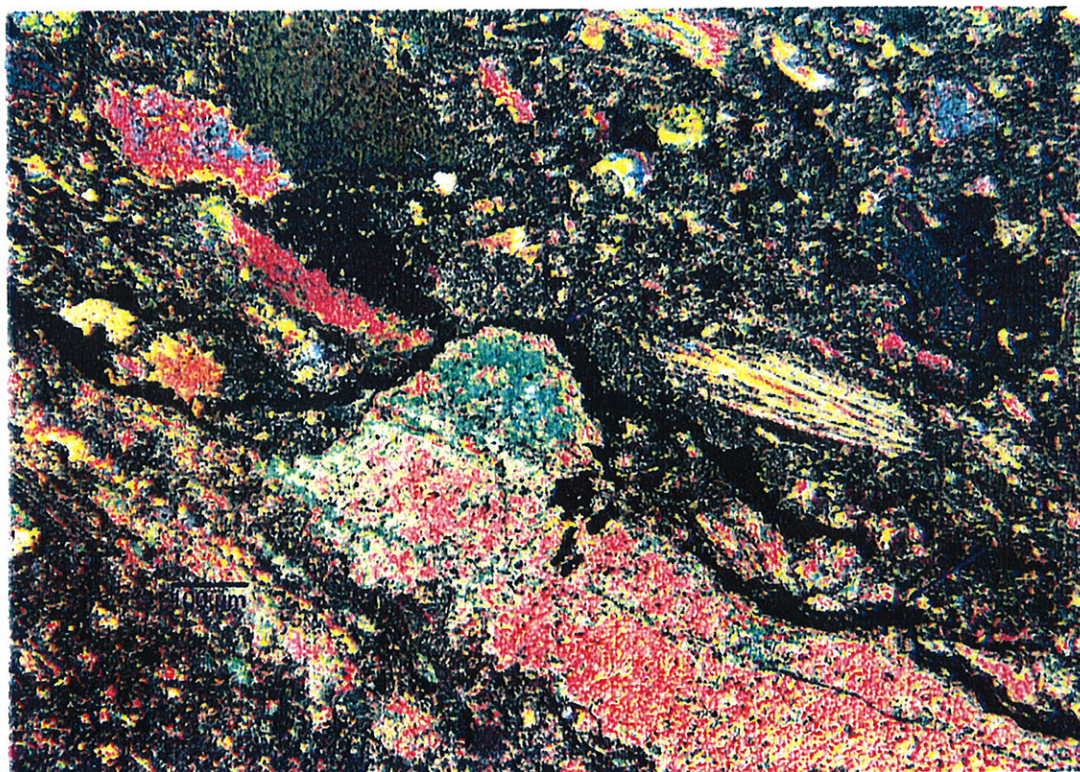


SAMPLE IDENTIFICATION: H,118.04-118.46 SAMPLE DESCRIPTION: Calcitic dolostone. Porespaces noted by blue arrows. plane polarized light.
MAGNIFICATION: 200x



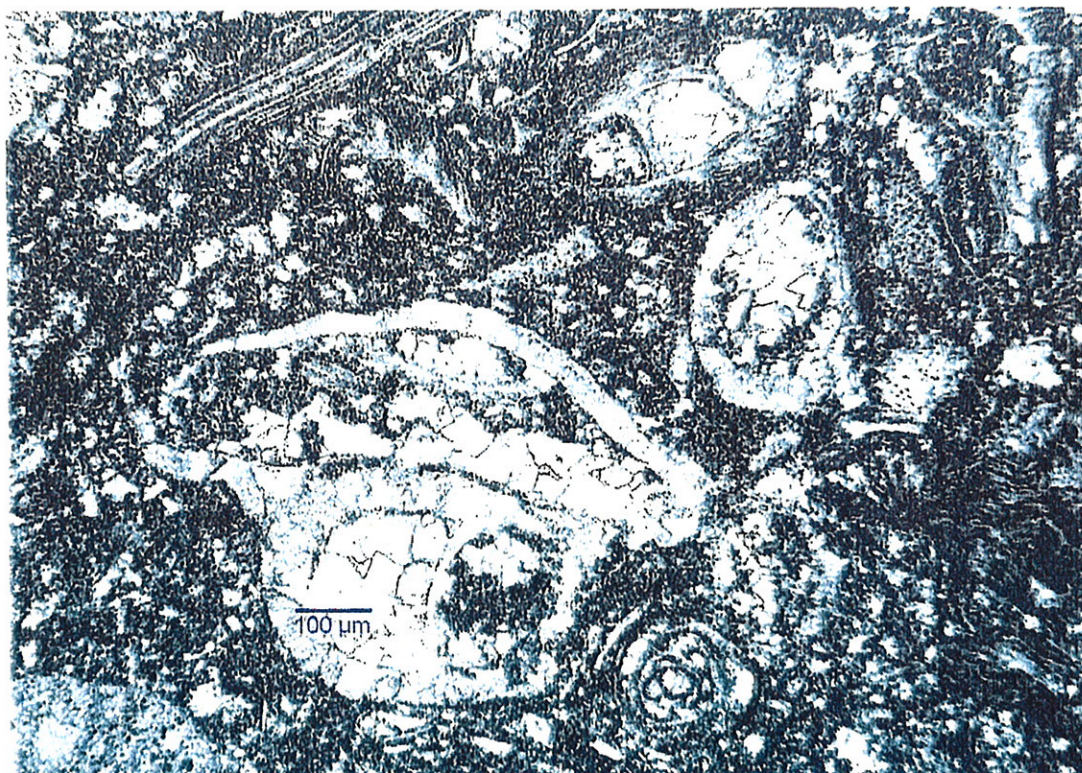
SAMPLE IDENTIFICATION: H,119.87-120.29 SAMPLE DESCRIPTION: Oo-pel-biosparite. Dense sparite cement. cross polarized light.

MAGNIFICATION: 100x

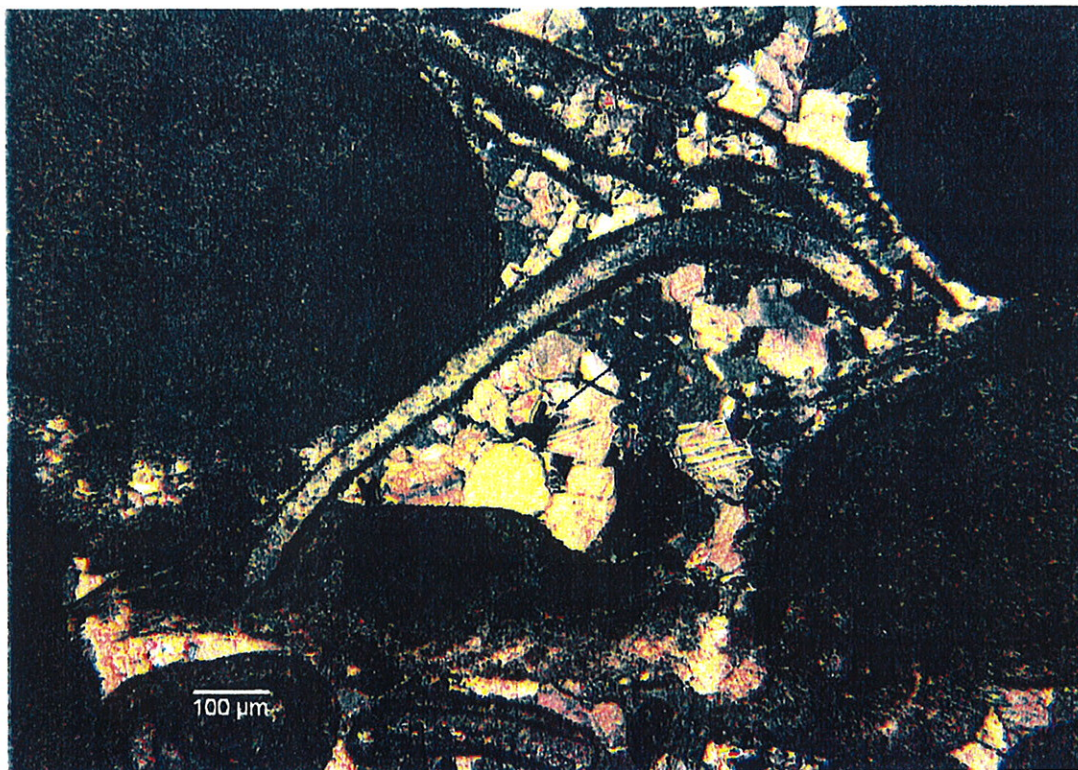


SAMPLE IDENTIFICATION: H,121.43-121.63 SAMPLE DESCRIPTION: Biosparite. Stylolite voidspaces noted by blue arrows. cross polarized light.

MAGNIFICATION: 100x



SAMPLE IDENTIFICATION: H,122.5-122.79 SAMPLE DESCRIPTION: Biosparite. Dense sparite cement surrounding fossil fragments. plane polarized light.
MAGNIFICATION: 100x

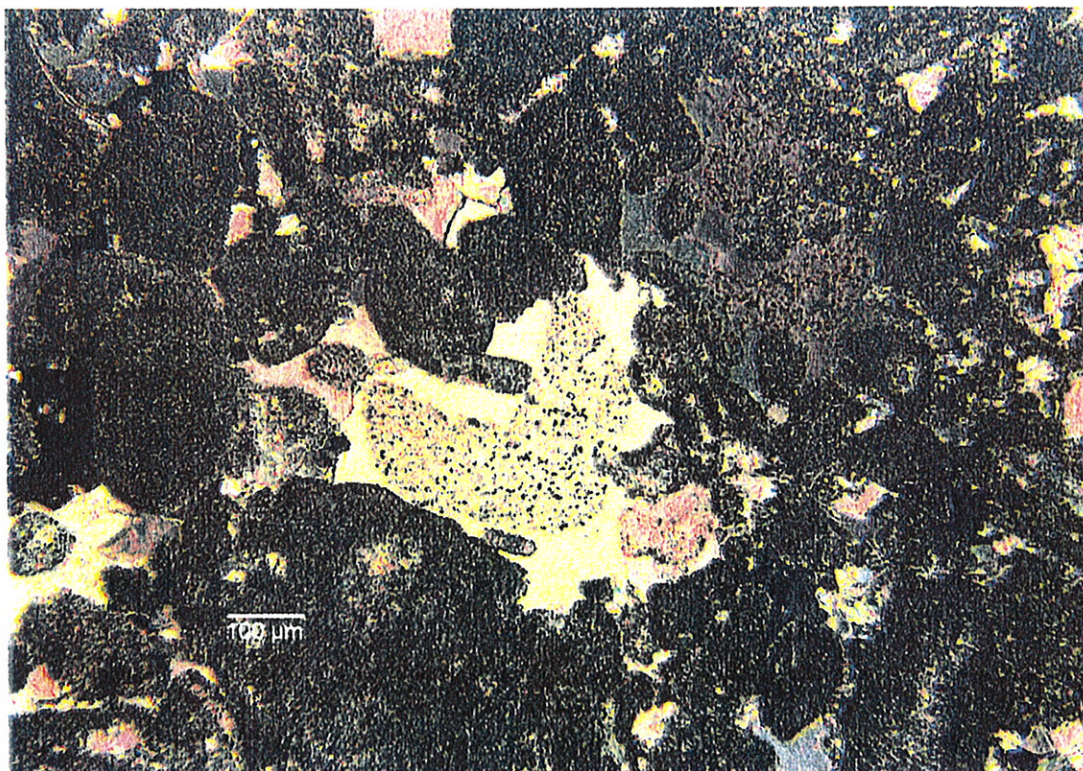


SAMPLE IDENTIFICATION: H,125.30-125.59 SAMPLE DESCRIPTION: Oo-pel-biosparite. Porespace in drusy sparite cement. cross polarized light.
MAGNIFICATION: 100x

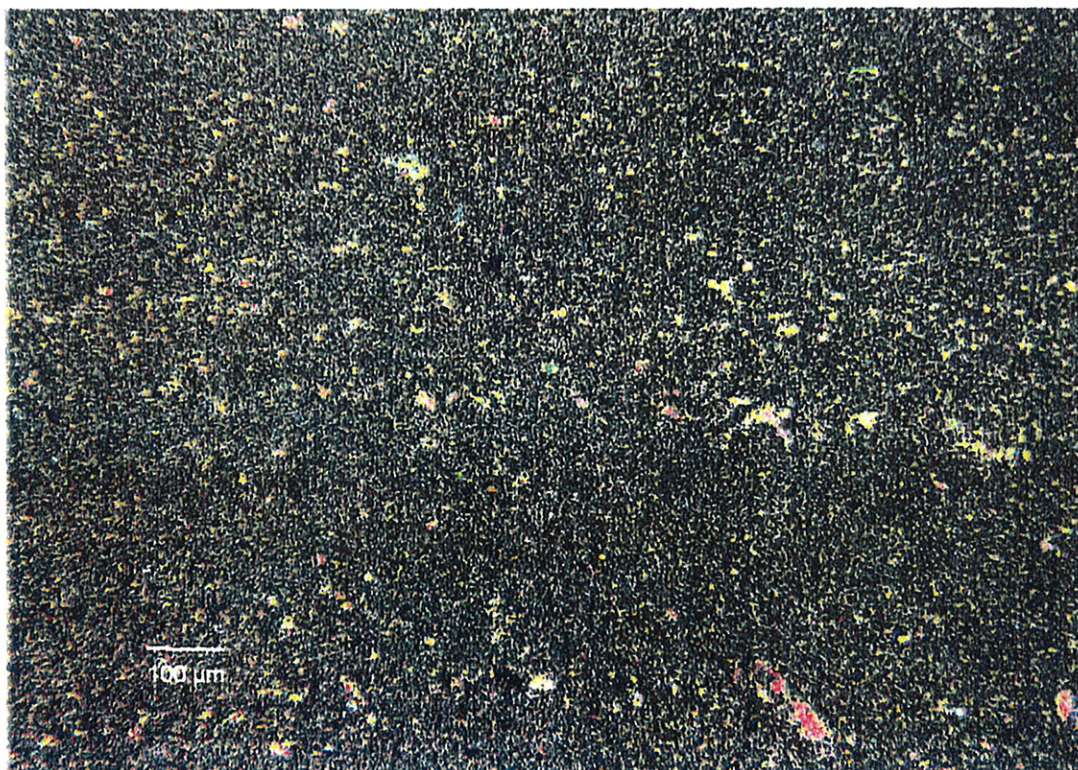
APS#
PROJECT:

10-01078
Solutia, Inc.
Sauget Area 1

DATE: JULY 12, 2000



SAMPLE IDENTIFICATION: H,128.99-129.39 SAMPLE DESCRIPTION: Pel-biosparite. Syntaxial sparite cement growth around echinoderm fragment (center). cross polarized light.
MAGNIFICATION: 100x

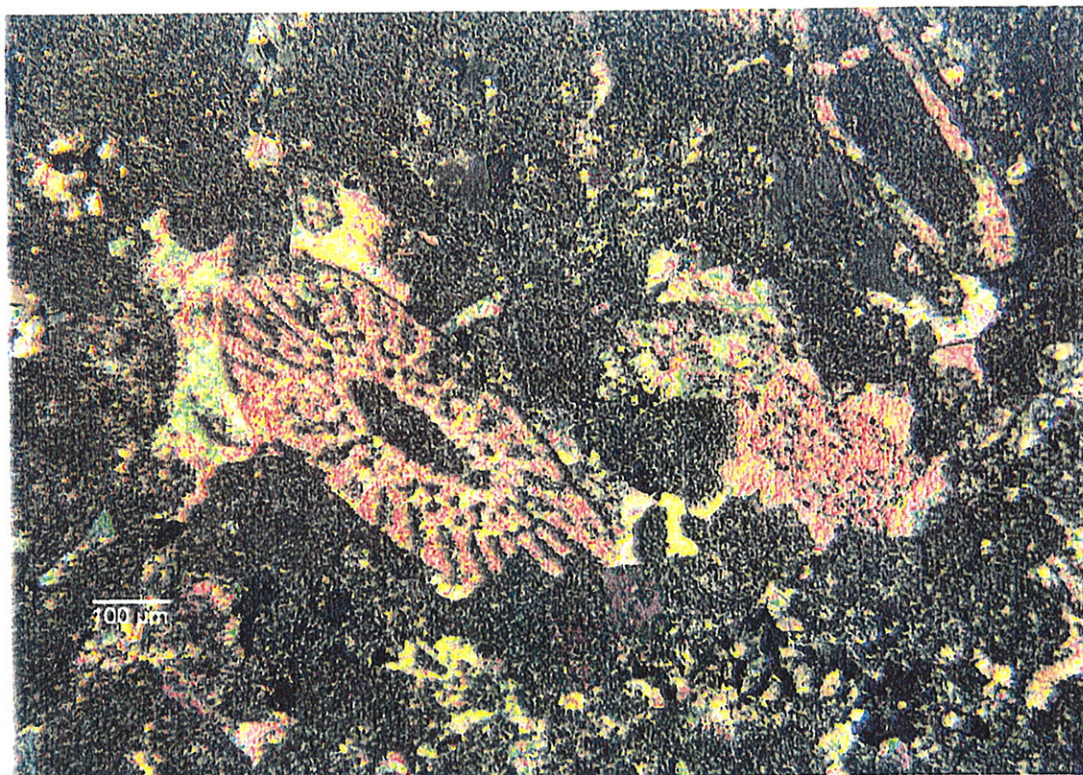


SAMPLE IDENTIFICATION: H,131.04-131.43 SAMPLE DESCRIPTION: Biomicrite. Dense micrite matrix. cross polarized light.
MAGNIFICATION: 100x

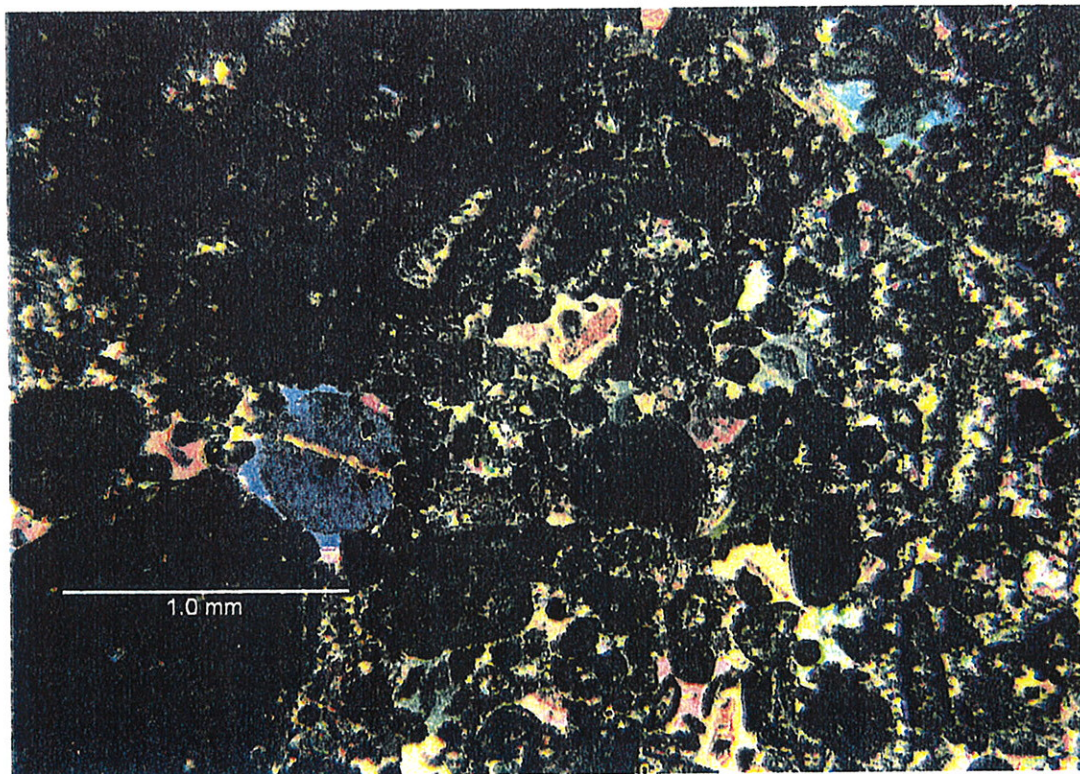
APS#
PROJECT:

10-01078
Solutia, Inc.
Sauget Area 1

DATE: JULY 12, 2000



SAMPLE IDENTIFICATION: I,127.54-127.92 SAMPLE DESCRIPTION: Pel-biosparite. Syntaxial sparite cement growth around echinoderm fragment (center). cross polarized light.
MAGNIFICATION: 100x

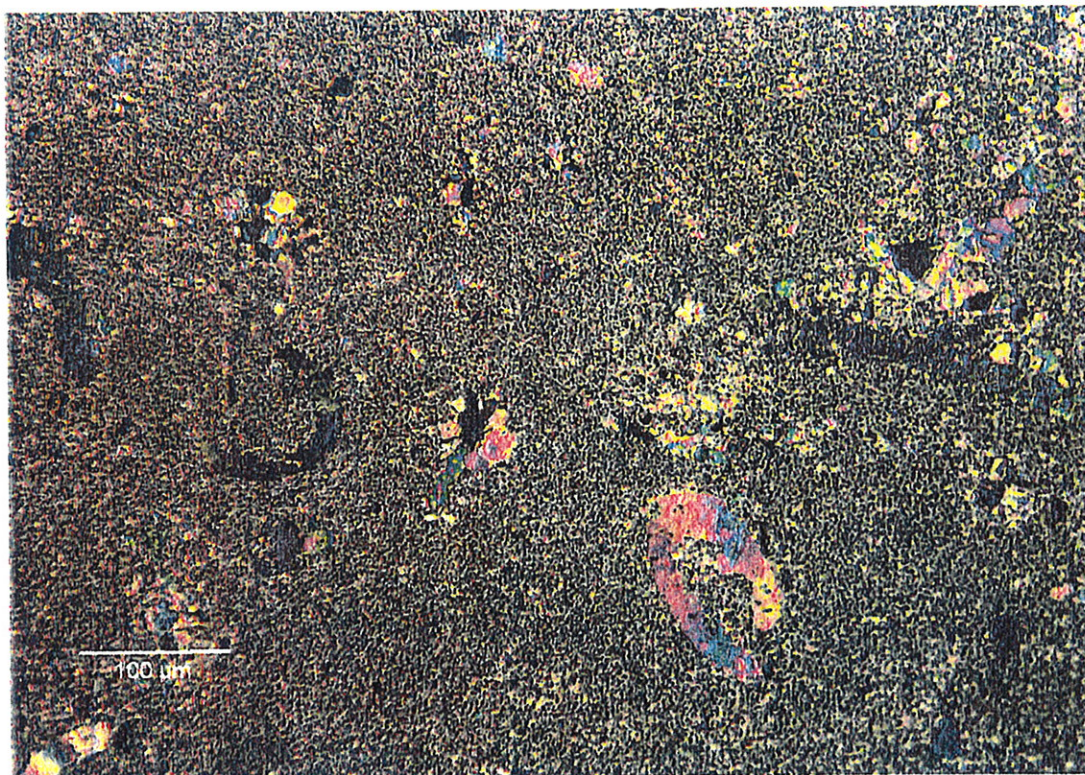


SAMPLE IDENTIFICATION: I,131.27-131.55 SAMPLE DESCRIPTION: Pel-biosparite. Dense sparite cement. cross polarized light.
MAGNIFICATION: 40x

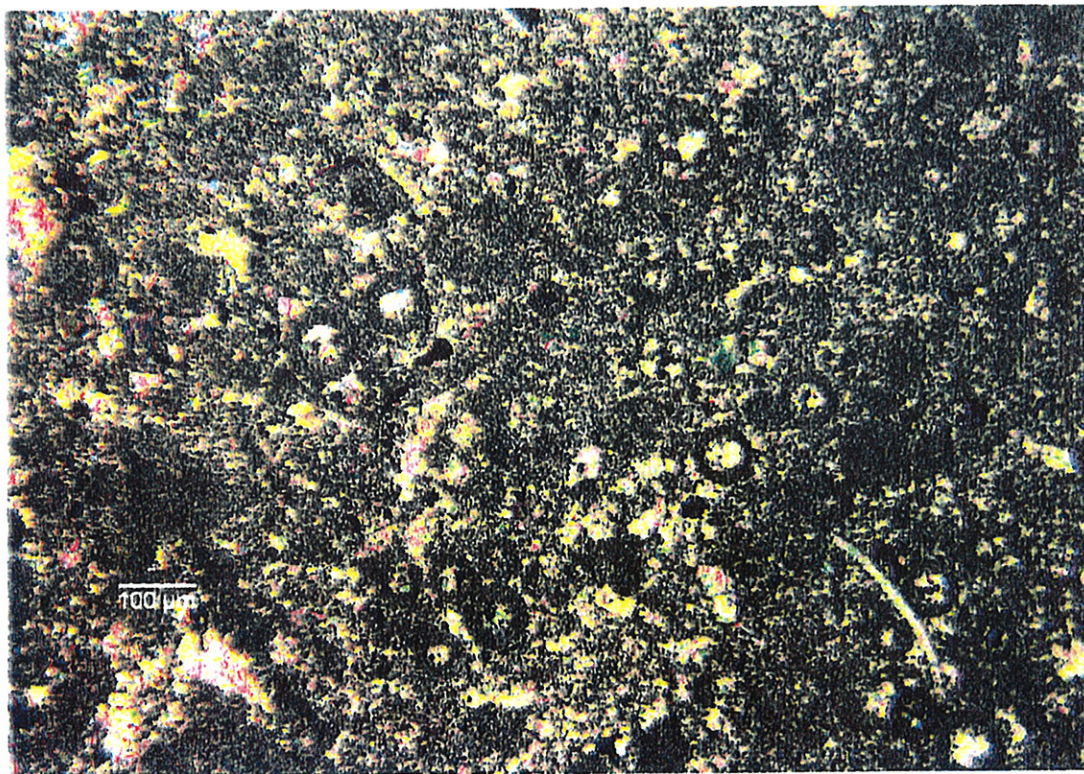
APS#
PROJECT:

10-01078
Solutia, Inc.
Sauget Area 1

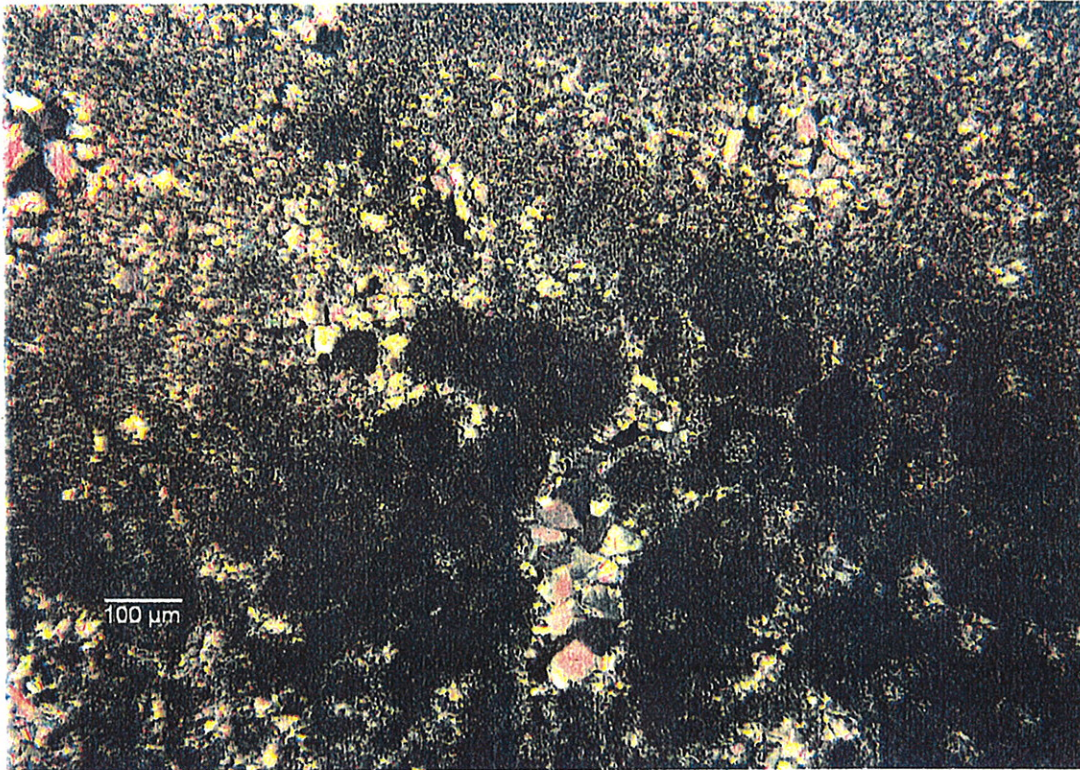
DATE: JULY 12, 2000



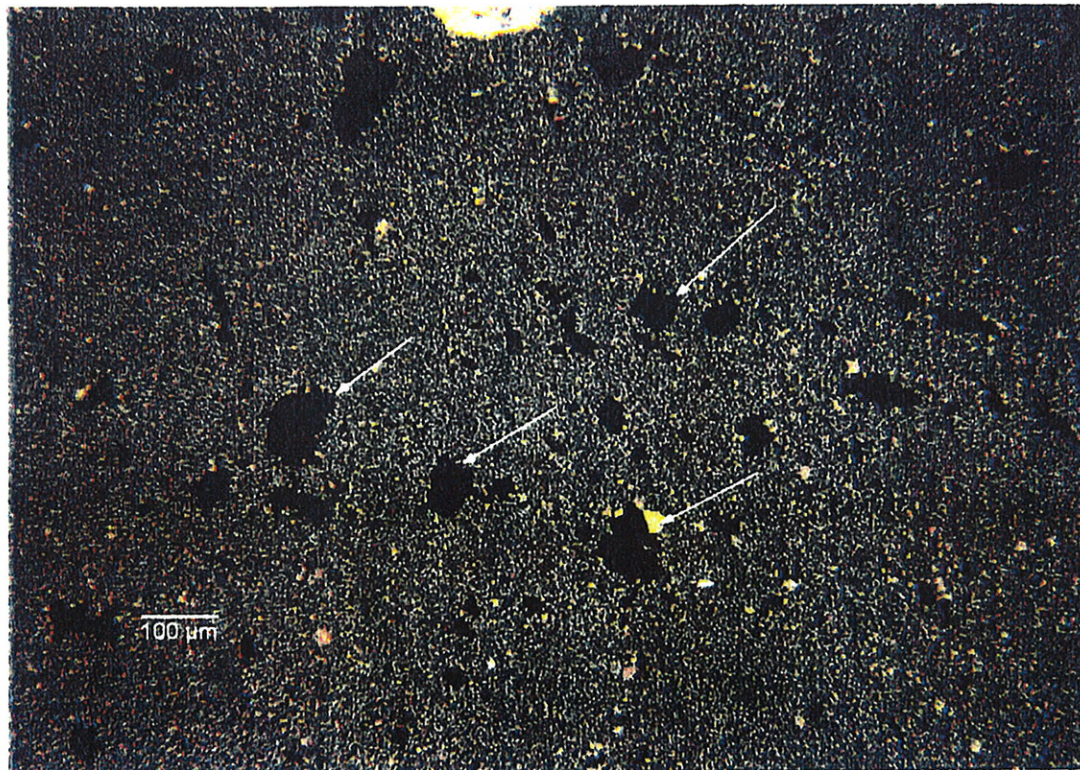
SAMPLE IDENTIFICATION: I,133.08-133.41 SAMPLE DESCRIPTION: Pel-biomicroite. Fossil fragments in a dense micrite matrix under cross polarized light.
MAGNIFICATION: 200x



SAMPLE IDENTIFICATION: I,134.59-135.01 SAMPLE DESCRIPTION: Oo-pel-biosparite. Dense sparite cement. cross polarized light.
MAGNIFICATION: 100x



SAMPLE IDENTIFICATION: I,137.61-137.84 SAMPLE DESCRIPTION: Pel-biosparite. Dense sparite cement under cross polarized light.
MAGNIFICATION: 100x

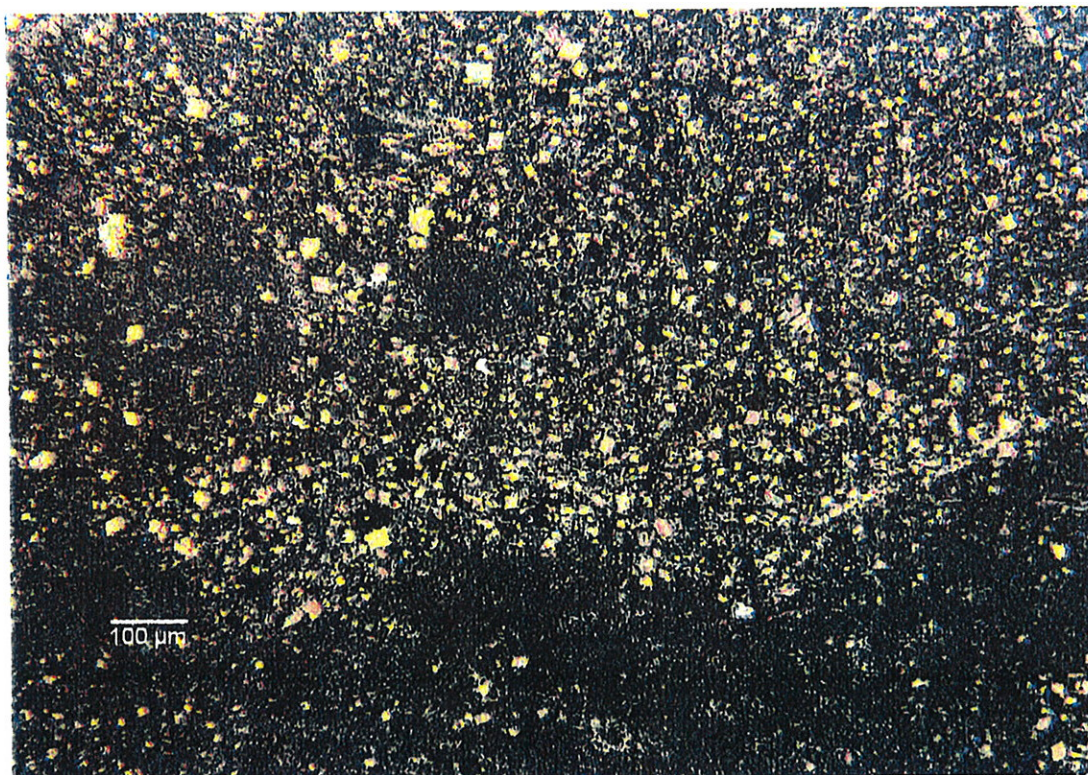


SAMPLE IDENTIFICATION: I,138.93-139.31 SAMPLE DESCRIPTION: Micro-sparite with many voidspaces which appear black under cross polarized light.
MAGNIFICATION: 100x

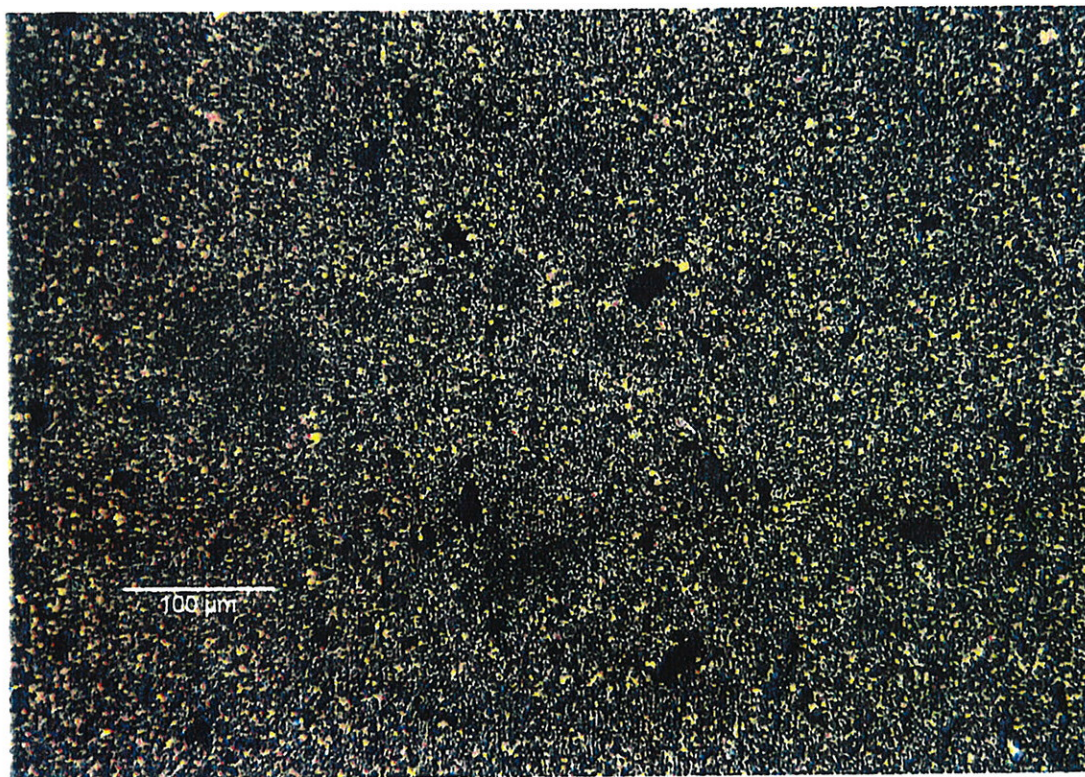
APS#
PROJECT:

10-01078
Solutia, Inc.
Sauget Area 1

DATE: JULY 12, 2000



SAMPLE IDENTIFICATION: I,142.57-142.87 SAMPLE DESCRIPTION: Dolomitic limestone. Black pore space in dolomitized area, under cross polarized light.
MAGNIFICATION: 100x

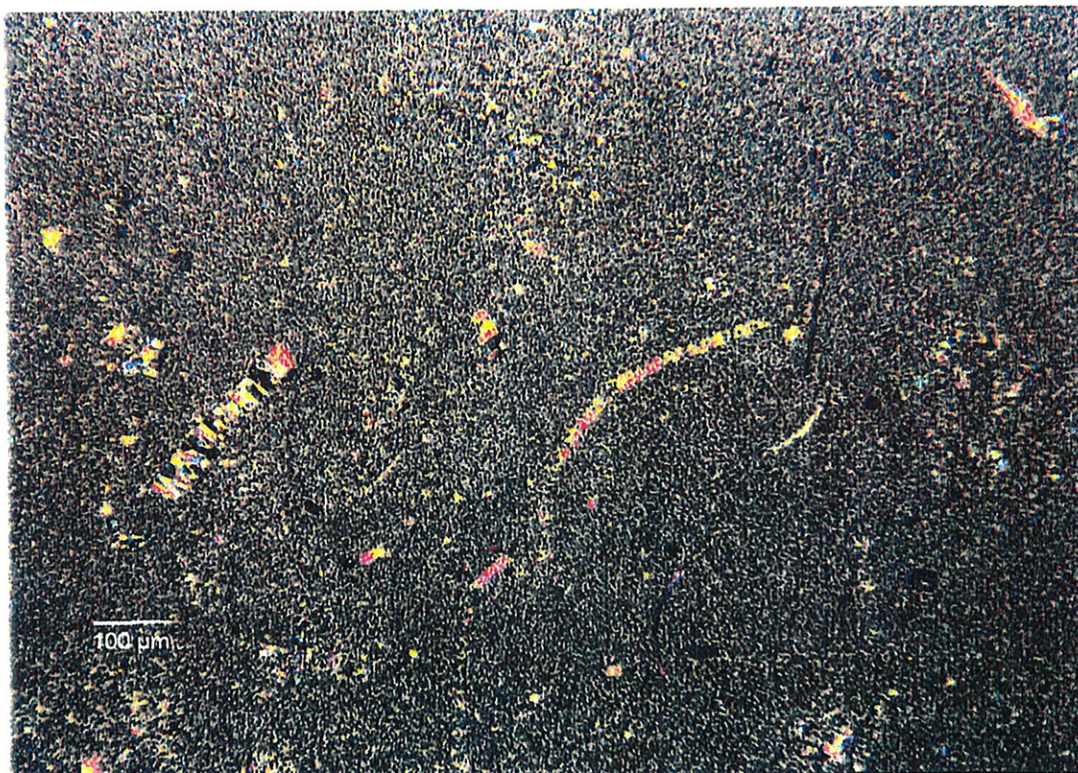


SAMPLE IDENTIFICATION: I,145.27-145.46 SAMPLE DESCRIPTION: Pelmicrite under cross polarized light. Some gray colored quartz silt was present. No visible porosity.
MAGNIFICATION: 200x

APS#
PROJECT:

10-01078
Solutia, Inc.
Sauget Area 1

DATE: JULY 12, 2000



SAMPLE IDENTIFICATION: I,146.63-146.88 SAMPLE DESCRIPTION: Biomicrite. Dense micrite matrix under cross polarized light.

MAGNIFICATION: 100x



AMERICAN
PETROGRAPHIC
SERVICES, INC.

October 12, 2000

O'Brien & Gere Engineers, Inc.
12250 Weber Hill Road
St. Louis, MO 63127

Attn: William Wright

Subj.: Solutia, Inc
Sauget Area 1
APS Job No. 10-01262

Dear Mr. Wright:

This letter presents the results of our observation made on one rock core samples. The scope of our work was limited to visually documenting the relative porosity of the selected area within the rock sample by thin section analysis. The sample was submitted by Mr. William Wright of O'Brien & Gere, Inc. on September 26, 2000. Our work was authorized at that time.

Observations

Sample	Lithology	Porosity	Comments
I, 129.85-130.27	Pel - bio sparite	Low	Dense, drusy sparite cement, syntaxial cement growth surrounds fossil fragments

Procedures

Thin section analysis was performed in accordance with APS Standard Operating Procedure 00 LAB 016, "Preparation of Thin Sections for Petrographic Analysis, APS Method". The selected sections of the core samples are first highly polished, then epoxied to a glass slide. The excess sample is cut from the glass and the slide is polished until the material reaches 25 microns or less in thickness. The resulting samples were reviewed under a petrographic microscope at magnifications up to 1000x. Our conclusions are based on the work performed, our observations, and experience. Laboratory testing was performed on October 2, 2000 and subsequent dates. Photos are included to illustrate our conclusions and observations.

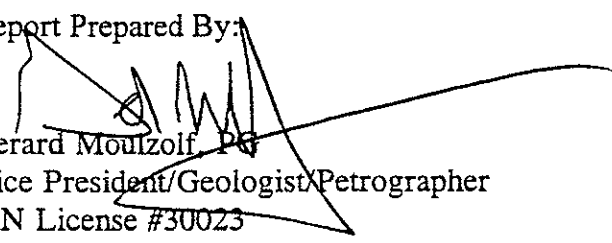
Mr. William Wright
October 12, 2000
Page 2

Remarks

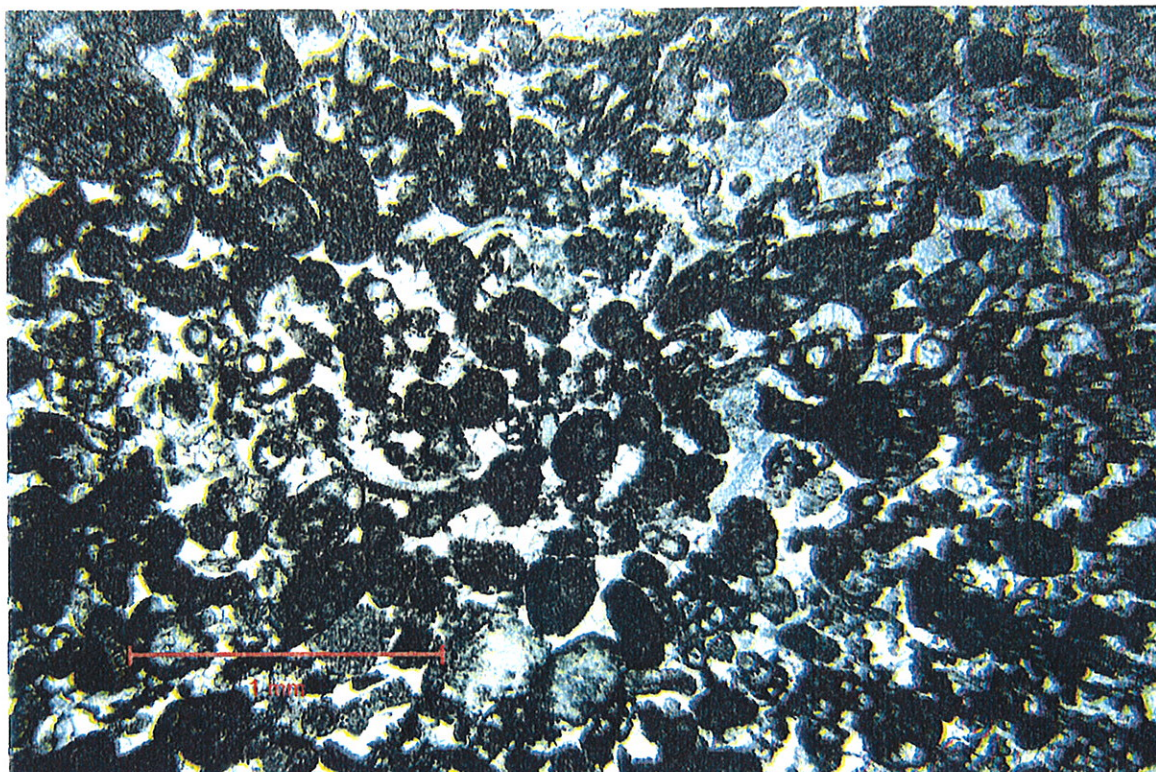
The core sample will be retained for a period of at least thirty days from the date of this report. Unless further instructions are received by that time, the sample may be discarded. The geologic services for this project have been conducted in a manner consistent with that level of care and skill exercised by members of the profession currently practicing in this area under similar budget and time constraints. No warranty, express or implied, is made.

If I can be of further assistance to you, please contact Gerard Moulzolf at (651) 659-1346.

Report Prepared By:

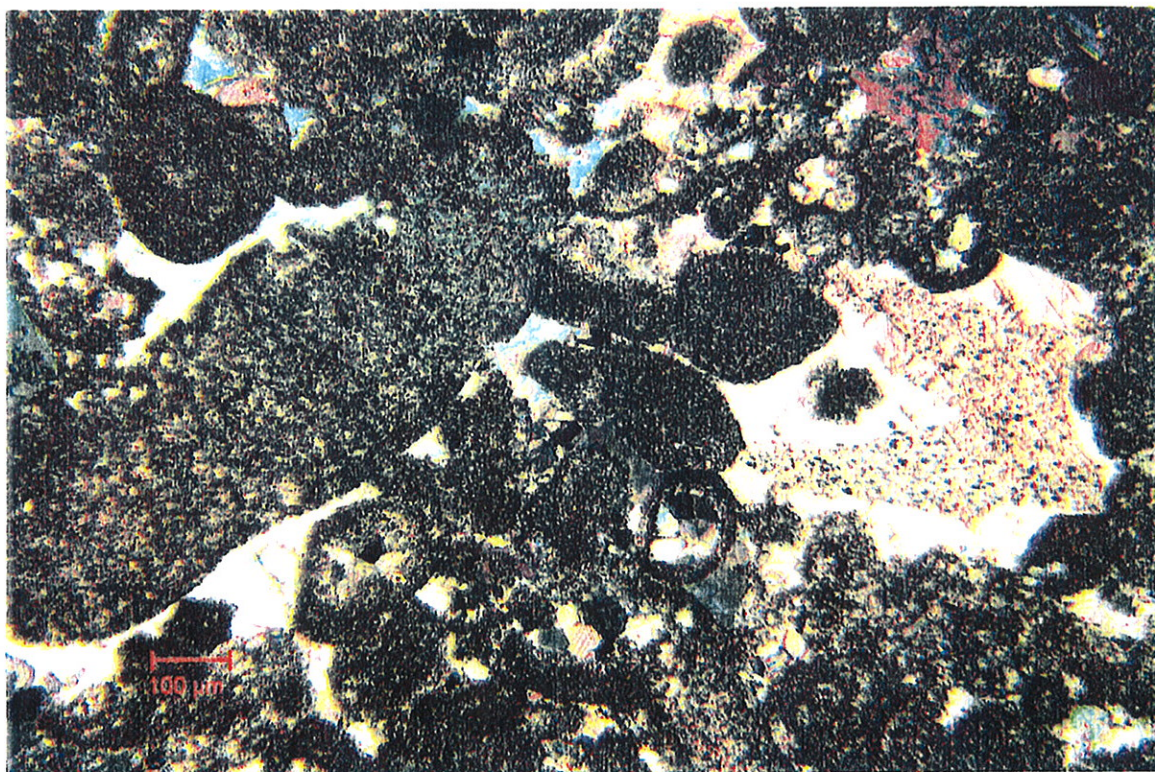


Gerard Moulzolf, PG
Vice President/Geologist/Petrographer
MN License #30023



SAMPLE IDENTIFICATION: I 129.85-130.27 SAMPLE DESCRIPTION: Pel - bio sparite. A thin section under plane polarized light

MAGNIFICATION: 40x



SAMPLE IDENTIFICATION: I 129.85-130.27 SAMPLE DESCRIPTION: Coarser sparite cement and syntaxial sparite cement fill voids between peloids and fossil fragments. Cross polarized light

MAGNIFICATION: 100x